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# **Dimensions of the self-concept in Autism Spectrum Disorder**

## Acknowledgements

*Firstly, on a professional note, I'd like to thank all of the participants who took part in this research and, in particular, the children, parents and staff of the following schools in County Durham and Northumberland: Cestria primary School, Gibside School, Kenton Park primary School, Lynnfield Community Primary School, Milecastle Primary School, Percy Hedley Lower School, St. Joseph's Catholic Primary School, St. Mary's Primary School, St. Paul's C of E Primary School and Valley View Primary School. Thank you also to Helen Rutherford and parents and children of the County Durham ASD parent and carer support group. And thank you to the North East Autism Research Group and to Deborah Riby and Jane Lidstone for all their help with participant recruitment.*

*Thank you to my supervisor, David Williams, for his continuing help, support and guidance over the last three years. And thank you to my supervisor, Madeline Eacott, for her time, patience and understanding. And thank you to Sophie Lind for all her help and support with this project.*

*Thank you to the denizens of L70, past and present. You know who you are, but special mention should probably go to Yan Birch, Kayleigh Carr, Alice Chadwick, Elizabeth Evans, Catherine Grainger, Hannah Harvey, Sophie Hodgetts, Katharina Kaduk Emma Lough , Peter Moseley, Anna Peel, David Smailes and Manuela Stets – you've all worn pointy hats, made banners and listened to my endless monologues about science fiction, drama and anything else I happened to think of. For that, you probably deserve medals. Thank you also to Helen Knight who is an honorary denizen of L70 and who has definitely listened to more than her fair share of monologues.*

*Thank you to Ooook! Productions and all who sail in her for letting me have a theatre to play in.*

*Thank you to Sophie Ray, the best housemate (and friend) anyone could wish for, even if she has instilled in me a lifelong fear of sleeping with the windows open...*

*And thank you to my family for many things, but particularly for their constant willingness to proof read very long documents at very short notice.*

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## **Abstract**

The self-concept can be separated into the physical self-concept (concerned with the self as a physical being) and the psychological self-concept (involving mental states, attitudes and beliefs). People with autism spectrum disorder (ASD) are thought to have an intact physical self-concept and an impaired psychological self-concept. Very little experimental work has previously been conducted directly comparing the physical and psychological self-concepts in ASD. This comparison is the primary aim of this thesis.

Chapters 1-3 utilise a self-referencing paradigm to investigate the strength of the self-referencing effect in relation to the physical and psychological self-concepts. Chapter 1 demonstrates the presence of the self-reference effect in typically developing adults in both physical and psychological domains. Chapter 2 shows that adults with ASD display self-referencing effect in both domains, while chapter 3 demonstrates that children with ASD (aged 8 – 10) show the self-referencing effect in the physical domain only. Chapter 4 sought to verify the existence of an unimpaired physical self-concept in ASD using the rubber hand illusion. Children with ASD performed at the same level as a comparison group. Chapters 5 and 6 used an autobiographical memory interview and a self-description task respectively to compare and contrast the physical and psychological self-concepts in ASD. On both these tasks, participants with ASD displayed impairments in the psychological domain only. Chapter 7 concentrates on the psychological self-concept alone and investigates the ownership effect in ASD. It was found that participants with ASD were impaired on this task.

Overall, the results presented here seem to support the idea that the psychological self-concept is impaired in ASD, while the physical self-concept remains intact. These are some of the first studies to directly compare the strength of the physical and psychological self-concept in ASD.



# Dimensions of the self-concept in Autism Spectrum Disorder

This thesis seeks to examine self-awareness and the self-concept in children and adults with Autism Spectrum Disorder (ASD). In particular, it focuses on the distinction between the physical self-concept and the psychological self-concept. The physical self-concept is taken here as being formed of ideas surrounding physical aspects of the self (for example, ideas to do with physical appearance and with the self as an agent of physical action), and the psychological self-concept is seen as being concerned with personality traits and emotional states. The idea that the physical self-concept is intact in ASD, while the psychological self-concept is impaired is explored in detail. The role of autobiographical memory in the self-concept is also examined. A secondary aim of the thesis is to explore the idea that the physical self-concept and the psychological self-concept are related, but separable, cognitive entities.

## The Typical Development of Self-awareness

In 1739, the philosopher, David Hume stated *'I can never catch myself at any time without a perception and can never observe anything but the perception'*. This illustrates the essential problem with studying the self, namely that it can never be studied in isolation from our perceptions of it. Hume argued that the study of the self independent from perception should not even be attempted. Instead, the focus of study should be on the perceptions themselves. This idea can and has been disputed (Shoemaker, 1994), but, what is clear is that these perceptions are of paramount importance to the study of the self. It is these perceptions which form 'the self-concept' and with which the majority of this thesis is concerned.

The cognitive structure of the self appears to be unique amongst other cognitive constructs. It is far-reaching and has both motivational and affective connotations

(Rodgers, Kuiper & Kirker, 1977). The self can be both the subject of experience and the object of experience. James (1890) equated the use of the term “*I*” with the subjective self and the use of the term ‘*me*’ with the objective self. Self-awareness is thought to occur when the self becomes the object of experience rather than the subject of experience. This idea was refined further by Butterworth (1995) who argued that “primary” self-awareness occurs when one is the object of one’s own perception, while “higher-order” self-awareness occurs when one is the object of one’s own cognition. Neisser (1988) proposes that self-awareness arises from five different sources of knowledge, namely the immediate physical environment, communication with others, memory, introspection and our position within society. The self therefore can be said to have both physical and psychological aspects with physical aspects including things like physical appearance and psychological aspects including emotional states, personality traits and so on (Gillihan & Farah, 2005).

The self is often seen to dominate a person’s emotional and cognitive interpretation of events. For example, there is a well-documented tendency to attribute one’s own motivations to situational factors, but the motivations of another to dispositional factors (Ross & Nisbett, 1991). The self is the cognitive basis for identity and for an individual’s unique position both within society and within a network of social relationships (Shantz, 1975). As the self-concept is of such paramount importance to all aspects of an agent’s interactions with, and perceptions of, the wider world, the study of it is a key topic in the study of human cognition (Gillihan & Farrah, 2005).

### **The Self in Infancy**

To begin to understand the self in adulthood, we must first examine its development in childhood. There has been relatively little research into the development of self-

awareness in typically developing infants and children, largely because many experimental tasks in this domain require skills that infants and young children do not have, such as linguistic proficiency and the ability to carry out complex motor movements. The recognition of the self in mirrors is seen as the first sign of the development of the physical self-concept and is thought to index self-awareness as an awareness of oneself as a physical entity. This is the first step towards a full understanding of the self as a cognitive entity separate from the surrounding environment. It is one of the few domains of self-understanding which can be reliably tested during infancy. This technique has been in use for over a hundred years – the first mention of it in the literature comes from the work of Charles Darwin (1877) who described how his nine-month-old son would look into a mirror and point at his reflection when he heard his name.

Nearly a century later, Dixon (1957) published a longitudinal study, charting infants' reactions to mirrors from the age of four months to the age of 12 months. On the basis of his observations, he proposed four stages in the development of self-recognition in infancy. At the first stage, the four-month-old infants show little interest in their own reflections, but are interested in the reflections of their mothers. At this stage, no self-recognition is said to be present. By the second stage, which typically occurs from four to seven months of age, infants become more interested in their own reflections. However, self-recognition is still not present as there is little distinction between the way the infant treats its own reflection and the way it treats the reflection of another infant. After around seven months of age, an infant will pay more attention to its own reflection than to the reflection of another infant and will start to imitate what is seen in the mirror. This is Dixon's third stage and is the first evidence of self-recognition and, in particular, the first evidence of distinguishing the self from another. The fourth stage

occurs at twelve months of age and, at this stage, the infant will typically appear embarrassed by its own reflection.

However, one problem is that the underlying cognitive basis of the behaviour shown by the infants in Dixon's study is rather ambiguous. Infants may simply be surprised to see something in the mirror which moves at the same time and in the same way that they do (Damon & Hart, 1982). A number of researchers have drawn attention to this potential problem with responses to mirrors as a measure of self-awareness. Schulman and Kaplowitz (1976), for example, found that infants under 24 months of age would react in the same way to a blurred mirror image and a non-blurred mirror image as long as both moved at the same time and in the same way that they did. Moreover, Papousek and Papousek (1975) presented infants under 12 months of age with video recordings of themselves and of another infant and found that infants showed no preference for looking at recordings of themselves. Instead they were more likely to look at the image which allowed them to make eye contact. This has led to the suggestion that infants are fascinated by mirrors, not because they recognise themselves, but because they are drawn towards making eye contact with the image in the mirror. The methodology used in these early studies does not allow us to ascertain whether or not this is the case.

This problem was overcome by the development of the mark test of mirror self-recognition. Amsterdam (1972) surreptitiously marked infants' noses with a lipstick and then placed them in front of a mirror, the theory being that infants with a knowledge of their own typical appearance (i.e., with a physical self-concept which is present in some form) would be surprised by the sight of the lipstick and that, those infants who recognised themselves in the mirror, would attempt to remove the lipstick from their own nose rather than from the mirror image. It was found that this kind of self-directed

behaviour did not occur until 18 months of age, suggesting that, contrary to Dixon's claims, conscious self-awareness does not occur until the end of the second year of life. Before this point, infants respond to the image in the mirror as though it is a peer rather than a reflection of the self. These findings have been replicated several times (Lewis & Brooks-Gunn, 1979; Nielsen & Dissanayake, 2004).

However, there are several criticisms of the mirror test of self-recognition, the most common of which is that passing the mirror test depends on an infant making fairly complex motor movements in order to attempt to remove the lipstick mark. Infants under 18 months may be surprised by the presence of the lipstick, but may lack the ability to communicate this. Other studies have suggested that the physical self-concept is in place in some form before the age of 18 months. For example, there is evidence that infants as young as two months old have some understanding of agency (the idea of themselves as agents capable of manipulating their environment) (Rochat, 2003). While not evidence of objective self-awareness, this does imply some understanding of the self as a physical entity. Lewis, Sullivan and Brooks-Gunn (1985), demonstrated that two month olds were able to learn to pull a cord to activate a toy and became distressed when the cord was cut, rendering their actions useless. These kinds of reactions imply that, by the age of two months, infants have some idea of themselves as entities with physical bodies capable of manipulating their surroundings.

Temporal recognition of the self (recognition of a self which remains stable through time) was assessed using videotape studies (Lewis & Brooks-Gunn, 1979) in which children were presented with live videotape images of themselves and images of other infants. Infants as young as nine months showed more interest in the live video images of themselves than the live images of other infants suggesting that they were able to

distinguish the self from others presumably based on the fact that the video image of the self is moving at the same time and in the same way that they are. However, a more recent replication by Suddendorf, Simcock and Nielson (2007) found that, while 90% of 24 month olds passed the mirror self-recognition task, only 35% of 24 month olds passed the same task when the mirror was replaced by live video feedback. The reasons for this deficit when live video feedback is considered are as yet unclear, but this study does indicate that mirror and video data should not be used interchangeably.

### **Self-Awareness in Childhood and Adolescence**

Mirror and videotape studies have yielded a lot of data regarding the development of self-recognition in infancy. However, they may not present a full picture of infant self-awareness as self-awareness is a concept which encompasses far more than physical appearance alone. Self-recognition of the kind tested by the mirror paradigm may only tap into the most basic level of self-awareness as evidenced by the fact that chimpanzees (Suddendorf, Simcock, Nielson & Collier-Baker, 2006), other great apes (Patterson, & Cohen, 2006) and even magpies (Prior & Schwarz, 2008) can pass self-recognition tasks. We know little about other modes of self-recognition in infancy (e.g. through hearing, smell or touch) and we do not know whether self-recognition or the lack of it is the full extent of self-understanding in infancy. In particular, we know almost nothing about the presence or absence of a psychological self-concept as this is difficult to study in pre-verbal children. In general, there is growing awareness of one's own emotions from early childhood onwards; many four year-olds are unable to vocalise how they are feeling, but they will demonstrate awareness of their emotions, by, for example, closing their eyes in order to focus attention away from an anticipated unpleasant stimulus (El-Sheikh, Cummings & Goetsch, 1989). Despite, these important developments, it has been found that before the age of seven, children will still tend to describe the 'self' in

exclusively physical terms (Damon & Hart, 1988). Of course, this does not prove that children below the age of seven do not have a psychological representation of the self, but, it does indicate that their focus is more on the physical and, importantly, that they prefer to define themselves in physical terms. This suggests that, at this age, the physical is perceived as being perhaps more important than the psychological.

Research into self-awareness with older verbal children takes a different form to the majority of research with infants. Rather than investigating visual self-recognition, most research with children concentrates on interview data, and is thus able to investigate both the physical and psychological self-concepts. One of the first studies to use this technique was conducted by Broughton (1978). He directly questioned children about their conceptions of the self by asking questions such as ‘what is the self?’ and ‘what is the difference between the mind and the body?’. He then used the answers to these questions to formulate a theory of the development of self-awareness throughout childhood.

Children may at first conceive of the self in purely physical terms (Broughton, 1978), often believing it to be part of the body (e.g. many children will claim that the self is situated in the head). Children at this stage will define themselves as entirely physical beings, for example they may say that they are different from another child because they are taller or have different colour hair. When a child is around seven years old, Broughton suggests that self-awareness becomes more sophisticated with less focus on the physical and more focus on the psychological. Children now describe themselves in terms of their thoughts and feelings. This suggests that the physical self-concept emerges at a significantly earlier stage of development than the psychological self-concept.

The shift from physical to psychological self-awareness suggested by Broughton has been supported by a number of empirical studies. For example, Guardo and Bohan (1971) asked children aged between 6 and 9 years firstly if they thought they could become just like another individual and then asked them for the reasoning behind their answer. All the children surveyed did not believe that they could become just like another individual, thus demonstrating a basic level of self-knowledge, but the reasons behind their answers differed strikingly with age. The six and seven year-olds typically stated that they could not become just like another named peer for physical reasons (e.g. the peer was a different gender or height etc.) while eight and nine year-olds gave these physical reasons, but also more psychological reasons relating to the likes and dislikes of the peer or to differences in personality.

It has also been suggested that, as well as defining the self in terms of physical appearance, young children also define the self in terms of physical actions. Keller, Ford and Meachum (1978) asked children aged between three and five to say ten things about themselves and it was found that 50% of responses related to physical actions such as “I play baseball”. The older children made an equal number of references to physical actions when describing the self as the younger children, but they did so in a different way; there was a tendency to describe their actions relative to the actions of others – for example, by saying “I can ride a bike better than my sister.” This comparison of the self to others has a psychological dimension.

The development of self-understanding through time can be charted effectively using qualitative methods. Damon and Hart (1986) devised a self-understanding interview designed for this purpose. The interview includes questions intended to assess the



concept of the self as subject and the concept of the self as object. Children's answers are divided up into four different levels, with the first two levels indicating only physical self-understanding and the second two levels indicating more sophisticated psychological self-understanding. Level one answers take the form of physical descriptions, while level two answers also incorporate ideas of the self as an agent of action. By level three, the psychological self-concept has become more important and children make frequent references to personality traits and social relationships in their answers. At level four, the self is defined largely in terms of fairly complex moral, philosophical, ethical and religious beliefs - children now see themselves as one piece in a larger social and societal jigsaw. The youngest children who can be tested using this kind of interview are around four years old and it is usually found that the majority of their answers are at level one. By the age of eleven or twelve, most children will be giving level four answers. The transition between levels two and three (or the shift between the physical and the psychological) typically occurs at around the age of seven.

However, there is evidence that some elements of the psychological self-concept may be in place before the age of seven. In particular, a sense of ownership over objects emerges much earlier. This is a psychological, rather than a physical, part of the self-concept as owned objects are considered to have a privileged cognitive processing status and are treated almost as extensions of the self (Beggan, 1992). A sense of ownership can also be felt over objects with which one has not had any form of physical contact. This is the psychological self-concept at its most physical and, perhaps, its most basic. Children as young as two display some awareness of ownership as evidenced by heated disputes over toys amongst siblings (Ross, 1996) and, by the age of four, children will show a memory advantage for pictures of owned objects over pictures of non-owned

objects demonstrating that a sense of ownership influences cognition from this age (Cunningham, Vergunst, MacRae & Turk, 2012).

In summary, the self-concept is predominantly, but not exclusively, physical before the age of seven and both physical and psychological after the age of seven. In other words, the emphasis within the self-concept shifts from physical to psychological during middle childhood. Whether or not the physical and psychological self-concepts can be seen as separate entities or are merely two aspects of one whole is an issue of some debate which will be explored further in the experimental chapters of this thesis. However, there is an emerging body of evidence to suggest that the physical self-concept and the psychological self-concept may be at least partially separable constructs. In particular, there is some suggestion that the physical and psychological self-concepts may have distinct neural correlates, with aspects of the physical self-concept, such as face processing, being associated with right prefrontal areas (Platek, Critton, Myers & Gallup, 2003) and elements of the psychological self-concept, such as autobiographical memory being linked to right parietal areas (Lau et al, 2004). Patients with asomatagnosia also perceive their own limbs as belonging to another person (a clear deficit of the physical self-concept), but show no recorded evidence of changes in personality or other aspects of the psychological self-concept. Asomatagnosia is usually caused by a lesion to the right supramarginal gyrus, implying that this area is implicated in the physical self-concept, but not the psychological self-concept (Feinberg, Haber & Leeds, 1990). In contrast, patients with lesions to the right frontotemporal regions often display changes in usually stable aspects of personality (Rankin, Baldwin, Pace-Savitsky, Kramer & Miller, 2005).

## **Memory and the Self**

One milestone in the development of the self is the emergence of autobiographical episodic memory (conscious, explicitly-recalled events relating to the self). This is thought to provide evidence of the existence of a self-concept which takes the form of a set of beliefs about the self (e.g. “I have blue eyes”, “I am good at tennis” etc.) (Neisser, 1988). This is a more sophisticated cognitive construct than pure self-recognition. This self-concept is thought to act as a fixed referent around which autobiographical semantic memory is based (Howe & Courage, 1997). It becomes developed enough to enable autobiographical memories to form at around two years of age (Harley & Reese, 1999), although this figure is something of an estimate, since the presence or absence of autobiographical memory cannot really be tested in children younger than two due to limited language skills.

The emergence of this type of autobiographical memory may in turn lead to the enhancement of self-awareness in general. For example, Povinelli (2001) has suggested that the relationship between autobiographical memory and self-awareness may be bi-directional with the development of a store of autobiographical memories allowing a child to form a temporally-extended self-concept which incorporates the idea that the self is the same entity in the past, the present and the future. This idea is supported by the fact that it is at around the age of two that children begin to be able to narrate events which have happened to them in the past (Crane & Goddard, 2008). However, this may also be influenced by developments in language skills at this age.

## **The Self-Reference Effect in Memory**

One important feature of memory in relation to the self is the self-reference effect. This is a cognitive bias present in the typical population. Cognitive biases can be described as ways of processing stimuli which favour particular interpretations of the world and the environment (Mathews & MacLeod, 2005). These biases often make certain features of the environment “stand out” or lead to certain interpretations of ambiguous stimuli. The self-referencing bias in particular means that stimuli relating to the self either implicitly or explicitly are processed before and in more detail than stimuli that do not relate to the self (Tversky & Kahneman, 1974). In everyday situations, these stimuli tend to take the form of words which can be used as self-descriptors or objects and words which are related to particular interests. However, in experimental situations, various manipulations can be used to cause stimuli which would not usually be self-referent to become self-referent. For example, the word “blond” can be made to be self-referent to a person who is not blond by placing it in the context of a self-referential question (e.g. “are you blond?”).

It has been suggested that such biases come about as a product of the availability heuristic, in which ambiguous interpretations of situations and events may be influenced by the ease of access to such events in memory (Tversky & Kahneman, 1974) and, events relating to the self, are for obvious reasons, easily accessible in memory. This means that the self-referencing bias is particularly apparent in memory. It is also present in the domains of attention and general cognitive processing.

Numerous studies have been conducted to investigate self-referencing. One of the first was carried out by Rodgers, Kuiper and Kirker (1977) who presented participants with to be remembered words in the context of various questions probing either surface or

semantic features of the word. Participants were also asked whether the word in question could be used to describe them and it was found that the words presented in this condition were recalled more accurately and quickly than words presented in either the surface or semantic encoding condition. One criticism of this study is that the questions relating to surface and semantic processing lacked a similar social element, meaning that the social dimension in general rather than self-referencing in particular may have led to memory facilitation. Kuiper and Derry (1982) addressed this issue by presenting participants with a list of words and asking them whether each word described either the self or a close other. Memory was enhanced for words relating to the self, but was not enhanced to the same degree for words relating to the other. In a meta-analysis of the relationship between memory and self-referencing, Symons and Johnson (1997) found that self-referencing was a more effective facilitator of memory than any other factor they considered including semantic processing.

One explanation for this is that self-referencing promotes both organisation and elaboration of to-be-remembered material. Organisation and elaboration are two highly effective strategies for encoding information in memory (Keenan, 1993). Elaboration involves attending to the specific meaning of an item which is to be remembered and then relating it to other items in memory. If the item which is to be remembered is related to the self then it is far easier to associate it with items already stored in long term memory (Einstein & Hunt, 1980). This kind of encoding is also thought to open-up multiple routes for retrieval which leads to easier recall of information (Klein, Chan & Loftus, 1989).

Organisation facilitates memory by encoding relationships between items which are to be remembered and which fall into a similar category. These categories can be based on

any kind of meaningful underlying dimension of similarity, but, in general, the larger the category, the more effectively it facilitates recall of information. Self-referencing, by its very nature, organises information into a large category (namely, that related to the self). Again, this organisation of material into categories leads to the development of multiple retrieval pathways (Kihlstrom, Albright, Klein, Cantor, Chew & Neidenthal, 1988). Another factor which leads to self-referencing facilitating performance on memory tasks is the fact that memory performance is, in part, dependent upon the level of relevant prior knowledge present. Since people generally have more prior knowledge about themselves than anything else, this leads to self-referent material being easily encoded and recalled (Markus, & Nurius, 1986).

### **Autism Spectrum Disorder**

Autism spectrum disorder (ASD) is considered to result from a dyad of cognitive deficits, and people with autism will typically show social and communication impairments, more specifically, impairments in social interaction (including a failure to develop relationships with peers and a lack of non-verbal behaviours such as eye contact), along with impairments in both verbal and non-verbal communication. Verbal communication impairments range from mutism to echolalia to a lack of pretend play in childhood. People with ASD will also show evidence of repetitive and stereotyped behaviours. Repetitive behaviours usually take the form of simple, repeated movements (for example, hand flapping) and strict adherence to rituals and routines which serve no obvious purpose (DSM-V; American Psychiatric Association, 2013). In addition to these symptoms, people with autism spectrum disorder may also display 'islets of ability'. These are areas in which the individual is exceptionally skilled (or at least performs at a level comparable to mental age matched controls). Islets of ability can take any form; a person may be exceptionally talented at playing a particular musical

instrument or they may be able to memorise an entire bus timetable. However, typically, areas of strength tend to lie in the domains of working memory and spatial reasoning (Happé, 1999).

As suggested above, the diagnostic criteria for autism are broad and the symptoms are varied. This has led to the idea that autism is not a unitary disorder, but is rather an umbrella term for a spectrum of disorders and, in fact the term ‘autism spectrum disorder’ (ASD) rather than ‘autism’ has now begun to be commonly used. The idea of a spectrum of disorders suggests that this spectrum may be able to be sub-divided into specific types or categories of autism. People with high functioning autism may be diagnosed relatively late in childhood, show no delay in language acquisition and have an IQ which is within the normal or high range (Wing, 1981). There is also a broader sub-clinical ‘autistic phenotype’ which is found within the typically developing population (Ronald, Happe, Price, Baron-Cohen & Plomin, 2006). As traits associated with ASD are continuous variables, they are found to varying degrees within the non-autistic population. In particular, first degree relatives of people with ASD, often show high, but still sub-clinical levels, of traits which are often associated with ASD (Constantino & Todd et al, 2005). This means that sometimes predictions can be made regarding the behaviours and cognitions of a group with ASD using data collected from a group without ASD, if the levels of sub-clinical autistic traits present in this group are assessed.

The underlying causes of autism are still a subject of some debate. Many early theories, such as the so-called ‘refrigerator mother theory’ (Bettelheim, 1967) which proposed that autism was caused by a cold and distant parenting style, have now been disproved and it has been found that there is no difference between parents of children with autism

and parents of others on various measures of personality (for review, see Herbert, Sharp & Gaudiano, 2002).

ASD is often defined as a behavioural disorder with a biological basis (support for this idea comes from various studies in molecular genetics which suggest that a particular combination of mutations of a set of genes is commonly associated with the presence of ASD. In particular mutations of CDH9, CDH 10 and MAPK3 may be associated with ASD, but the evidence for this is as yet inconclusive. (Abrahams & Geschwind, 2008)). However, this merely describes the disorder. In order to explain it, a cognitive theory is required. Currently, there are three major cognitive theories of autism, namely the 'mindblindness' hypothesis (Baron-Cohen, 1985), the executive function theory (Ozonoff & McEvoy, 1994) and weak central coherence theory (Frith & Happe, 1994). The majority of the following section will be concerned with the 'mindblindness' hypothesis.

### **Cognitive theories of Autism**

The mindblindness hypothesis is concerned with the idea that people with autism lack theory of mind. Wimmer and Perner (1983) defined theory of mind as the understanding that other people have their own beliefs about and interpretations of the world around them. In other words, it is the ability to impute mental states to the self and to others in order to explain and predict the behaviour of others. As the attribution of mental states to others is something which occurs fairly automatically in the neurotypical population, the term 'mentalising' is sometimes used instead of theory of mind, since this places less emphasis on active, conscious cognitive processes. In typically developing children, this capacity to understand the mental states of others gradually develops over time and



leads to an appreciation that others have minds of their own (Bauminger & Kasari, 1999). Arguably, it begins to develop at around 18 months of age when children start to form second order representations of the world around them (Leslie & Roth, 1993). These are sometimes known as ‘M-representations’ and refer to the ability to see others as thinking beings with their own perspectives on reality. The emergence of these types of representations is showcased by the emergence of pretend play.

One of the most commonly used tests of theory of mind (TOM) is the Sally-Anne task (Baron-Cohen, Leslie and Frith, 1985) in which children are presented with two dolls, one named Sally and one named Anne. Sally has a marble which she hides in a box while Anne watches. Once Sally has left the room, Anne moves Sally’s marble from the box to a basket. When Sally returns she begins to search for her marble and children are asked where Sally will look first. Typically developing children over the age of four understand that Sally will look in the box as she did not see Anne move the marble. Typically developing children under the age of four and children with ASD fail to appreciate this and suggest that Sally will look in the basket first since this is where the marble really is. In other words, they fail to understand that Sally can have a false belief about the marble’s location, thus implying that they fail to understand that Sally has a unique viewpoint on the world. The results of this task would suggest that an understanding of ToM does not occur until around the age of 4. However, this is at odds with the idea of pretend play abilities emerging at around the age of 18 months. This may be a result of the performance-competence distinction; in other words, children under the age of 4 may also be competent enough at understanding false belief tasks to pass the Sally-Anne task, but they may not perform well enough on the particular task being used due to a failing of the task rather than a failure to understand ToM. It may therefore be necessary to find some other way of reliably assessing ToM ability in the

under-4s in order to be able to say with confidence when exactly the ability to understand ToM appears.

The Sally-Anne task and other false belief tasks concentrate on children's understanding of the minds of others. Indeed, TOM is often described as having an understanding of the minds of others, but encapsulated within theory of mind is the concept of theory of own mind. Indeed, Wimmer and Perner's original definition of TOM referred to the ability to attribute mental states to others *and to the self* in order to predict behaviour. This idea centres around the fact that the ability to recognise mental states in the self and in others may be dependent upon the same core set of cognitive mechanisms and processes (Carruthers, 2009). Simulation theory is another key theory in this debate and suggests that the ability to recognise mental states in others is dependent upon having direct, first-person access to one's own mental states, so that the mental states of the self can be used to 'simulate' the mental states of others and to predict the behaviour of others (Goldman, 2006). This is of direct relevance to the arguments of this thesis since it suggests that TOM ability (particularly in relation to theory of own mind) and the strength of the psychological self-concept are very closely related as the strength of the psychological self-concept is dependent the ability to access one's own mental states, traits and emotions.

Although the majority of research into TOM has concentrated on awareness of the minds of others, a number of studies have investigated theory of own mind in ASD. A very commonly used test of TOM is the unexpected contents or 'Smarties' task (Leslie & Thaiss, 1992). Just like the Sally-Anne task, the smarties task tests the idea of false belief; children are presented with a smarties tube and asked what they think the tube contains. After saying that they think the tube contains smarties, they are then shown

that the tube contains a small pencil. They are then asked what another person coming into the room would think was in the tube. The children who believe that this new person would think the tube contained a pencil are said to lack understanding of false belief and, with it, TOM. Unlike the Sally-Anne task, the smarties task contains a 'self' test question in which children are questioned about their own beliefs prior to looking inside the smarties tube. When asked to repeat what they *said*, children with ASD will pass the self test, since this is merely a test of memory. However, when questioned about what they had previously *believed*, children with ASD will often erroneously state that they had always believed that the tube contained a pencil, thus implying a potential failure of theory of own mind (Baron-Cohen, 1991; Fisher et al, 2005).

This idea was built upon by Williams and Happe (2009) who used a version of the Smarties task in which children demonstrated their false beliefs through their actions (when asked to fetch plasters, they looked inside a plaster box which turned out to be full of candles. In a second condition, a confederate did the same thing). In this way, the false belief was never verbalised. It was found that, under these conditions, children with ASD were more likely to fail the self-test question than the other test question. In other words, they were more likely to understand that the confederate had a false belief about the contents of the box than that they themselves did. This is very compelling evidence for a failure of theory of own mind. It also provides an explanation for one of the most compelling arguments against TOM impairments being a core deficit in ASD, namely the fact that a small minority of those with ASD pass false belief tasks. The finding that children with ASD are relatively more impaired when understanding their own mental states than when understanding the mental states of others suggests that people with ASD may learn to predict the mental states and beliefs of others using atypical or alternative rule-based mechanisms which do not depend necessarily on TOM

ability. These same rules are unlikely to be able to be generalised to predicting one's own mental states and behaviours. Therefore, the fact that a small minority of those with ASD pass conventional TOM tasks may not provide evidence against the TOM account of ASD *per se*.

Understanding one's own mind incorporates an understanding of one's own intentions. This may also be an area of some difficulty in ASD. During a virtual reality shooting game in which hitting certain targets accidentally resulted in a prize while hitting the intended targets did not, Philips et al (1998), found that children with ASD were far more likely than typically developing children to report that they had hit the accidental targets on purpose. This implies some confusion between desire and intention, since the children desired to obtain the prize, but did not intend to complete the action which resulted in gaining the prize. Similarly, after an automatic knee-jerk response has been elicited, children with ASD will often claim that the movement was intentional (Williams & Happe, 2010).

A lack of theory of mind could explain many, if not all, of the social deficits seen in autism. It may also explain why autistic individuals of all IQ levels display essentially the same social deficits since theory of mind develops independently of IQ. People with ASD also have a primitive difficulty perceiving biological motion which may be linked to their mind-blindness (Annaz, Campbell, Coleman, Milne & Swettenham, 2012; Annaz, Remington, Milne, Coleman, Campbell, Thomas et al, 2010)

The mindblindness hypothesis is an appealing explanation for many of the symptoms of autism, but there are problems with it, one of which is the issue of diagnostic specificity. Children with congenital blindness or deafness will often show similar

theory of mind deficits to children with ASD, but will show few behavioural features of ASD (Peterson & Seigal, 1995; Peterson, Peterson & Webb, 2000). However, this may again be a result of the performance – competence distinction; children with congenital blindness or deafness may well understand ToM, but may be failing the Sally-Anne task and other, similar, measures for unrelated reasons. The mindblindness hypothesis also does not account for all the deficits seen in the disorder. In particular, it does not account for the adherence to routine seen in autism or for the strength in spatial reasoning which is sometimes present. Weak central coherence (WCC) theory (Frith & Happe, 1994) attempts to account for these features. This account suggests that people with autism fail to seek ‘global coherence’, instead focusing only on small details of both social interactions and other types of perception. This would explain why individuals with autism often focus on routines and details and seek ‘sameness’. It also provides an explanation for why people with autism may not appear to place social interactions in their wider context.

However, WCC Theory does not obviously explain the repetitive, stereotyped movements often seen in those with ASD. The only theory to date which does account for this aspect of autism is the executive function (EF) theory (Ozonoff & McEvoy, 1994). The idea of executive dysfunction in autism was put forward after the similarities between the symptoms of autism and the symptoms of damage to the frontal lobes and other executive areas of the brain were noted. Such symptoms include a need for sameness and difficulty switching between different stimuli. In particular, this difficulty in switching attention between different stimuli may account for many of the deficits seen in autism (Muller, Zelazo & Imrisek, 2005). Various attempts have been made to test executive function in people with autism. However, the results are generally inconclusive. For example, Bennetto, Pennigton and Rogers (1996) found that many

people with autism perform poorly on the Tower of London task, but people with AD/HD, Tourette's Syndrome, obsessive compulsive disorder and schizophrenia also perform poorly on this task as do people with a low IQ. This means that it is impossible to tell whether executive dysfunction is a core feature of autism, a symptom of a co-morbid disorder such as AD/HD or a consequence of low IQ.

### **Autism and the Sense of Self**

These accounts all have various strengths and weaknesses, a discussion of which is beyond the scope of this thesis. What we do know is that autism as a disorder has always been intrinsically linked with the concept of the self. Indeed, the word *autism* is derived from the Greek word *autos*, meaning 'self'. Early psychologists such as Bleuler (1905) viewed autism as an extreme form of egocentrism, an almost total focus on the self. Today, many psychologists instead see autism as being just the opposite, namely the absence of a sense of self (Frith, 2003).

Children with autism under the age of seven years often do not pass the mirror self-recognition task (described above), implying that they have failed to recognise the mirror as an image of the self (Spiker & Ricks, 1984). However, these children tend to have a mental age which is much lower than their chronological age. In some cases it is lower than 18 months, the age at which mirror self recognition would occur in typically developing (TD) children. One suggestion is that the deficit seen in some children with ASD during the mirror self recognition task is due to the presence of a low mental age rather than to a deficit in self recognition. In other words, mirror self-recognition is mental-age appropriate in ASD (Ferrari & Matthews, 1983). In fact self-recognition is sometimes seen as a relative strength for individuals with autism as they often perform

at the level of mental age matched peers when recognizing delayed video images of themselves (Lind & Bowler, 2009). When presented with images of their faces, morphed in varying percentages with the face of another, children with ASD are able to recognise those morphs which are comprised mainly of their face with the same degree of accuracy as a mental age matched typically developing (TD) sample. They also showed comparable activation of the right prefrontal/premotor system to a TD group when viewing images comprised mainly of the self (Uddin, Davies, Scott, Zaidel, Bookheimer, Iacoboni, et al, 2008).

This would suggest that the self-concept in ASD has elements which are largely intact. However, it must also be remembered that the mirror task tests only the recognition of the self as a physical entity; it does not assess recognition of the self as a psychological being.

It may be that the shift from predominantly physical to predominantly psychological self-awareness which occurs in typically developing children occurs much later in children with ASD or may not fully occur at all. This would mean that the psychological concept of the self would be impaired, but the physical concept of the self would not. The idea that children with ASD may have intact physical self-awareness is supported by evidence from Williams and Happe (2009). They found that both high and low-functioning children with ASD performed at the level of their typically developing peers on a task which required them to discriminate between self and other caused changes in their environment. Similarly, children with ASD are able to recognise delayed video images of themselves which suggests the existence of a temporally extended physical self-concept (Lind & Bowler, 2009). These effects extend to the domain of memory with adults with ASD displaying an enactment effect

(enhanced memory for self-performed actions vs. the observed actions of another) of the same strength as that observed in typically developing adults (Grainger, Williams & Lind, 2013).

However, these pieces of evidence cannot be used to imply that children with ASD have an intact psychological self-concept and it has been suggested that children with ASD are impaired in this domain (Neisser, 1988). This idea is supported by a range of evidence from neuroimaging studies, suggesting that neural processing related to the self occurs slightly differently in those with autistic spectrum disorders. In typical individuals, the anterior insula, middle cingulate cortex, ventral premotor cortex and somatosensory cortex will all show similar patterns of activation both when a person is performing a particular action and when they are watching another performing the same action, while the ventromedial prefrontal cortex makes a distinction between self and other referent processing and does not respond when the agent is simply observing the actions of another (Moran, MacRae, Heatherton, Wyland & Kelley, 2006). In contrast, in autism, the ventromedial prefrontal cortex does not appear to make this distinction (Lombardo, Chakrabati, Bullmore, Wheelwright, Sadek & Suckling, 2009). This, combined with the fact that patients with ventromedial prefrontal lesions, display many symptoms which are reminiscent of autism, has led to the suggestion that an impaired ability to distinguish the self from others in certain domains, such as pronoun use, caused by abnormalities in the ventromedial prefrontal cortex may underlie many of the deficits seen in ASD (Loveland & Landry, 1986).

The presence of an impaired psychological self-concept in ASD may be linked to the difficulties in relating to others encountered by those who have the disorder. Simulation Theory suggests that typical individuals use an understanding of the self as a starting



point for understanding others. In other words, typical individuals understand the minds of others by a comparison of how they differ from and are similar to the mind of the self (Goldman, 2006). Simulation theory therefore predicts that those who have an impaired self-concept may find it difficult to relate to and understand others. This seems to be the case in autism.

Other symptoms of ASD may also be traced back to underlying deficits in psychological self-awareness. For example, people with autism often display specific language problems, including often talking about themselves in the third person and other difficulties with using pronouns (Toichi, Kamio, Okada, Sakihama, Youngstrom & Findling, 2002). People with ASD also often display alexithymia, showing little understanding of their own emotions (Shalom, Mostofsky, Hazlett, Goldberg, Landa, Faran, et al, 2006) and mental states (Williams & Happé, 2009). The direction of causation of this impairment in ASD is unclear. The diminished psychological self-concept may be a cause of the social and communication impairments seen in ASD, but, equally, it may be a consequence of them. Deficits in the social and communication domains may lead to an individual having only limited opportunities to acquire psychological self-knowledge, but would not reduce opportunities to acquire physical self-knowledge, since physical self-knowledge is acquired through experience with mirrors and other non-social situations. If individuals with ASD have an impaired psychological self-concept, this may lead to deficits in autobiographical memory, because the development of autobiographical memory depends strongly on the existence of an intact psychological self-concept (Conway & Rubin, 1993).

### **Autism and Memory**

Individuals with autism typically show a specific pattern of memory strengths and weaknesses. For example, they often display intact and, in some cases, enhanced, associative memory, cued recall, rote memory and echoic memory, while visuo-spatial working memory and time based prospective memory appear to be impaired, along with autobiographical memory (Boucher & Lewis, 1992; Shalom, Mostofsky, Hazlett, Goldberg, Landa, Faran, et al, 2006; Williams, Jarrold, Grainger & Lind, 2014)

This pattern of memory strengths and weaknesses is able to exist because memory is comprised of a number of different systems within the brain that process information in parallel, meaning that one memory system can remain intact while another is impaired (Squire, 2004). In particular, a distinction is made between declarative memory, memory for facts and events, and non-declarative memory, memory for skills. Non-declarative memory incorporates memories based on priming, perceptual learning and classical conditioning while declarative memory is more conscious and context dependent (Schacter & Tulving, 1994). Declarative memory can in turn be divided up into episodic and semantic memory (Tulving, 1983).

The difference between episodic and semantic memory is the difference between remembering something and knowing something; episodic memory is linked to a specific context and usually to a feeling of reliving a past event, while semantic memory is not linked to any particular moment in time. For example, general knowledge such as the fact that Athens is the capital of Greece is stored in semantic memory. Similarly, the meanings and spellings of words are known even though the actual moment of learning them is often not remembered. Tulving (1985) devised the “remember/know” paradigm which distinguishes between episodic and semantic memory. During this test, participants are presented with a number of items and then later, presented with these

items again and are asked whether they specifically remember the item in question being presented or whether they just know in a more general sense that it was presented. In studies where this paradigm is used with people with ASD, it is usually found that participants with ASD and control participants will perform at the same level when asked to pick out items previously seen during the study from amongst novel items, but, when asked if they remember specific items being presented or whether they simply know that they were presented, participants with ASD will give far more “know” responses than typical participants (Bowler, Gardiner & Grice, 2000). This suggests that an impairment in episodic memory is present in ASD, while semantic memory remains intact. In particular, people with ASD may find it difficult to remember the context in which a certain fact was learnt or in which a certain event occurred.

It may be that people with ASD do not process episodic and semantic information in the same way as others, meaning that an increased number of ‘know’ judgements among people with ASD may have occurred for reasons other than an impairment of episodic memory. However, the study described above utilised both high and low frequency words and, it was found that both people with ASD and people without ASD showed an increased number of “remember” judgements when presented with low frequency words as opposed to high frequency words. The persistence of this pattern across both groups provides support for the idea that episodic memory rather than semantic memory is impaired in ASD.

Episodic memory of any kind may be dependent upon the existence of self-awareness, meaning that these results would provide support for the suggestion that self-awareness is impaired in ASD (Wheeler, Stuss & Tulving, 1997). However, others would argue that material must be encoded in a specifically self-referential way for it to involve self-

awareness (see Northoff, Heinzl, de Greck, Bermpohl, Dobrowolny, & Panksepp, 2006, for review). Since material presented in the remember-know task does not have to be processed in a specifically self-referential way, it does not provide sufficient evidence for the existence of an impairment of self-awareness in ASD. The remember-know paradigm also taps into the distinction between noetic and auto-noetic consciousness where noetic consciousness is the recall of an event (knowing) and auto-noetic consciousness is the recall that the event in question happened to the self ('remembering'). Traditionally, only auto-noetic consciousness has been linked with consciousness, episodic memory and with self-awareness (Tulving, 2002). This view divides noetic and auto-noetic consciousness into two distinct and separable categories, but in reality the boundaries between the two may be a little less solid; in particular, auto-noetic consciousness is usually said to include a feeling of 'mental time travel' and or reliving past experiences (Conway & Playdell-Pearce, 2000). However, these feelings do not always occur during recall of past events even when the context of these past events is recalled (Crawley & Eacott, 2006), suggesting that some episodic memory may be noetic in nature. However, the suggestion remains that, in ASD, memory for the context of events is impaired whilst memory for more factual information remains intact. This leads us on to consideration of the literature relating to episodic autobiographical memory.

The most striking pattern of memory deficits seen in autism occurs in episodic autobiographical memory. This is memory for specific personally experienced events. There is some controversy over when exactly autobiographical memories start to emerge in developmental time, with some researchers suggesting that children over the age of two years possess the cognitive capacity for autobiographical memory (Howe & Courage, 1997), while others feel that this form of memory develops only after the age

of four (Perner & Ruffman, 1995). What is clear is that typically developing individuals display 'childhood amnesia', a paucity of memories from early childhood (Eacott & Crawley, 1998). This phenomenon is generally thought to be linked to episodic rather than semantic memories and may be linked to the development of self-awareness over time. People with autism continue to show this same pattern of impaired recall of episodic memories in late childhood and adulthood. They show limited recall of past events, little recall of context and will only generate small numbers of autobiographical memories when prompted (Russell & Jarrold, 1999). Further deficits in autobiographical memory were demonstrated in a study by Losh and Capps (2003) in which participants with ASD and control participants were asked to narrate events depicted in a picture book and narrate events from memory (e.g. by telling the experimenter about the last holiday they had been on or similar). It was found that, while participants with ASD performed at the level of the control group when describing the events in the picture book, they were significantly impaired when narrating events from memory.

This deficit seems to be restricted to autobiographical episodic memory and does not appear to extend to autobiographical semantic knowledge. In a case study of RJ, an individual with ASD, it was found that RJ had detailed semantic knowledge of his personality traits, but he had great difficulty in describing incidents where he had demonstrated these traits (Klein, Chan, & Loftus, 1999). These results are supported by those of Crane and Goddard (2008) who interviewed a number of high-functioning adults with ASD and again found that autobiographical episodic memory was impaired, but not autobiographical semantic knowledge.

This idea of an impairment in autobiographical episodic memory is supported by evidence from Goddard, Howlin, Dritschel and Patel (2007) who presented participants with a series of cue words designed to elicit memories of specific events. It was found that participants with ASD were much slower at generating specific memories than control participants and they also generated far fewer memories in response to each cue word. During the course of the same study, participants were asked how they would go about solving a number of social problems (e.g. how they would go about making up with a friend after an argument). This task was designed to give participants the opportunity to describe particular memories without the pressure of direct questioning. It was found that, while, participants with ASD were just as likely as those without ASD to suggest ways of solving the social problems, they were far less likely to describe specific memories during the course of this.

Autobiographical episodic memory is a form of self-referential memory and the fact that it is impaired in autism seems to suggest that the self-referencing bias seen in typical individuals may not be present in individuals with autism. Several studies have investigated the presence of the self-referencing bias in autism directly. Toichi et al (2008) presented participants with personality trait adjectives in the context of questions. These questions either elicited surface level processing (e.g. “does the word rhyme with...?”), semantic level processing (e.g. “is the meaning of the word similar to...?”) or a self-reference effect (e.g. “does the word describe you?”). Control participants remembered more of the words in the self-referencing condition than in the other two conditions, while participants with ASD remembered equal numbers of words in the self-referencing and semantic conditions. This work was built on by Lombardo, Barnes, Wheelwright and Baron-Cohen (2007) who asked participants whether a number of trait adjectives could be used to describe either themselves, their best friend

or a fictional character (in this case, Harry Potter). Typical participants recalled a greater number of words from the self-referencing condition than from the best friend or Harry Potter conditions, as did participants with autism. However, strikingly, the differences in the numbers of words recalled in each of the three conditions were reduced in autism, and, in particular, the difference between the self and Harry Potter conditions was very small, implying that the self-reference effect is reduced in autism.

However, if self-awareness is late developing in ASD, rather than completely absent, the self-referencing effect may present differently in children. Henderson, Zahka, Kojkowski, Inge, Schwatz and Hileman (2009) repeated Lombardo's study with children rather than adults. In children, the performance of the group with ASD differed drastically from the performance of the control group as the children with ASD displayed an almost complete absence of the self-referencing effect. This implies that self-awareness develops significantly with age in those with ASD and is in line with evidence from the studies of mirror recognition described above in which children with ASD often display mirror recognition at a later point in developmental time than their typically developing peers. This provides evidence for the idea that the development of self-awareness may be delayed in ASD. It must be remembered though that both these studies failed to distinguish between physical and psychological trait adjectives and thus tested only the presence of the self-concept as a whole rather than focusing specifically on the physical or psychological self-concept. In particular, no study to date has successfully demonstrated either the complete presence or absence of the psychological self-concept in ASD.

## **Outline of Thesis**

The above discussion suggests that the self-concept may have both physical and psychological aspects and, furthermore, suggests that the psychological self-concept is impaired in ASD, while the physical self-concept remains intact. A secondary issue which has been raised is the idea that the physical and psychological self-concepts may be distinct and separable cognitive entities, or, alternatively, they may be two aspects of the same cognitive construct. Therefore, in the next seven chapters, a number of experiments will be presented which attempt to explore the psychological and physical self-concepts in adults and children with autism spectrum disorder as well as the idea that the physical self and the psychological self may be distinct cognitive entities.

The first chapter uses a self-referencing paradigm (similar to those described above) with a group of typically developing adults. The self-referencing effect is examined in relation to the physical self-concept and the psychological self-concept separately. This first chapter was intended to establish the existence of the self-referencing effect in both the physical and the psychological domains. In chapter two, this paradigm is employed with a group of adults with autism. Chapter three builds on the results of chapter two by exploring the development of the self-reference effect in primary school age children with autism.

Chapter four concentrates on the physical self-concept alone and looks at the sense of body ownership in children with ASD. Following the results of the self-reference chapters, this was intended to show that the physical self-concept in children with ASD was at the same developmental level as the physical self-concepts of their typically developing peers.



Chapters five and six revisit the idea of a comparison between the state of the physical self-concept and the psychological self-concept in ASD. This time qualitative methodology is employed to give a fuller sense of the autobiographical experiences of people with ASD. Chapter five examines autobiographical memory in adults with ASD while chapter six is concerned with the self-descriptions of children with ASD.

Chapter seven examines the ownership effect in adults with ASD. Chapter seven was not intended to examine the differences between the states of the physical and psychological self-concepts in ASD, but instead was intended to provide some evidence for the idea that the physical and psychological self-concepts are distinct cognitive constructs. The ownership effect was chosen because it is a facet of the psychological self-concept which emerges at a very early point in developmental time. Therefore, if the self-concept is one construct, the development of which is truncated at around the age of seven in ASD, then the sense of ownership in ASD should be unimpaired since this emerges before the age of seven. If, however, the psychological self-concept is something separate from the physical self-concept then it is likely to be impaired from birth in ASD, meaning that the sense of ownership should not be present. Chapter eight then presents the general conclusions of the thesis.

# **Chapter One: The Self-reference Effect and its Relation to Subclinical Autistic Traits**

As stated in the general introduction, the central aims of this thesis are to assess the distinction between the physical and psychological self-concepts in autism spectrum disorder, and to examine whether or not the physical and psychological self-concepts are cognitively distinct, separable entities. This first study uses the self-reference effect to examine possible distinctions between the physical and psychological self-concepts within a population of typically developing adults. Correlations between the strength of the self-referencing effect and levels of autism like traits are also examined.

The presence of a self-reference effect arguably implies the presence of a self-concept – it is suggested that the self-reference effect is attributable to the fact that the self-concept acts as an effective structure for the organisation and elaboration of material within memory (Symons & Johnson, 1997). However, to our knowledge, no studies to date have drawn a distinction between performance in response to psychological trait adjectives and performance in response to physical trait adjectives, meaning that the strength of the self-referencing effect has not been directly compared across physical and psychological domains. As these two facets of the self-concept appear to be dissociable, it is possible that they may exert independent influences over memory processing. Since the physical self emerges earlier in developmental time, it could be hypothesised that the self-reference effect will be greater and more robust in the physical domain.

In Experiment 1.1, a group of adult participants were tested using a standard self-reference paradigm which incorporated both physical and psychological stimuli. In addition to this, participants completed a measure of autistic-like features which can be used to measure both clinical and subclinical levels of traits seen in individuals with

ASD. ASD traits show a normal distribution in the general population (Ronald, Happe, Price, & Baron-Cohen, 2006), which is in keeping with the view of autism as a “spectrum” (Wing & Gould, 1979), whereby the distinction between “neurotypical” and clinical ASD is made arbitrarily. As such, it should be possible to explore possible deficits (e.g. in psychological self-awareness), that are typical of individuals with clinical diagnoses, among individuals displaying subclinical levels. It was predicted that level of autistic traits would be negatively correlated with the self-reference effect in the psychological domain, but not in the physical domain.

The purpose of this experiment was twofold; firstly, it was intended to examine the previously unstudied distinctions between the physical and psychological self reference effects, and, secondly the relationship between results and self-reported measures of self-awareness, with a particular focus on the relationship between the self-reference effect and autism-like traits.

We predict that both physical and psychological self-reference effects will be present. It is also predicted that there will be a correlation between levels of self-reported self-awareness and the strength of the self-reference effect.

### **Method: Experiment 1.1**

#### **Participants**

Participants were 50 (41 female) Durham University undergraduate and postgraduate students, aged between 18 and 32. No participant had a history of neurological or psychiatric disorders, according to self-report, and no participant had a current or past diagnosis of autism spectrum disorder. This was verified by their performance on the Autism Spectrum Quotient (Baron-Cohen, Wheelwright, Skinner, Matin & Clubley, 2001) (described below). Ethical approval was obtained from Durham University

Research Ethics Committee. Informed, written consent was given by all participants. Participants were reimbursed for their time or received course credit for their participation.

## **Overview**

Participants completed the self-referential memory task followed by the Autism-Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) and a questionnaire designed to measure self-awareness. All participants completed all parts of the study in one testing session which took approximately an hour.

## **Materials and Procedure**

### **Selection of stimuli and task design**

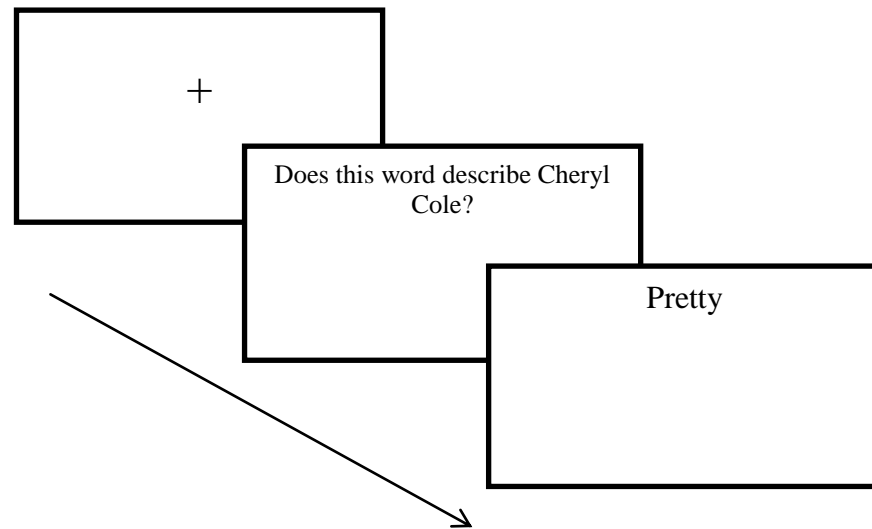
One hundred and fifty adjectives (see Appendix 1), half of which were judged to describe personality traits/psychological characteristics, and half of which were judged to describe physical traits, were selected for use in the study. The adjectives were selected from validated lists compiled by Anderson, (1968) which gave ratings for ‘meaningfulness’ (how well the word is understood) and ‘likability’ (how positive the trait is judged to be). Physical and psychological adjectives selected for inclusion in the study were matched on these two measures so that enhanced or impaired performance on one particular word type could not be attributed to differences in meaningfulness or likability. A Multivariate analysis of variance (MANOVA) was conducted and returned non-significant results for both meaningfulness,  $F(1, 149) = 0.16, p = 0.69, \eta^2 = .001$ , and likability,  $F(1,149) = 0.26, p = 0.61, \eta^2 = .002$ , meaning that physical and psychological words did not differ significantly on measures of meaningfulness or likability.

Three counterbalanced versions of the task were created. Each version comprised three sub-lists of 50 (25 physical and 25 psychological) adjectives, namely 50 adjectives to be used in the self-referent encoding condition, 50 to be used in the other referent encoding condition and 50 to be used as lures at test. The sub-lists were rotated through the counterbalanced versions, such that each sub-list appeared as self-referential target items in one version, other-referential target items in one version, and lure items in one version.

### **Study phase**

During the study phase, 100 trait adjectives were presented on a laptop (using Microsoft PowerPoint), half in the self-referential encoding condition and half in the other referential encoding condition. In the self-referential condition, participants assessed whether or not the adjective described them. In the other-referential condition, they judged whether or not the adjective described a gender-matched celebrity (Simon Cowell for male participants and Cheryl Cole for female participants – both well known in the UK). Each adjective was presented, following a question designed to elicit either self-referential or other-referential processing, for example *“Does this word describe Cheryl Cole?: ‘Pretty’”*. The structure of the questions was identical between the self- and other-referential conditions. Participants were instructed to respond verbally to each question by saying either ‘yes’ or ‘no’. Adjectives were presented in a pseudo-random order, subject to the constraint that no more than four physical or four psychological trait adjectives appeared consecutively, and no more than four self- or other-referential questions were presented consecutively. Each adjective was presented for 3 seconds. Figure 1.1 illustrates the trial procedure.

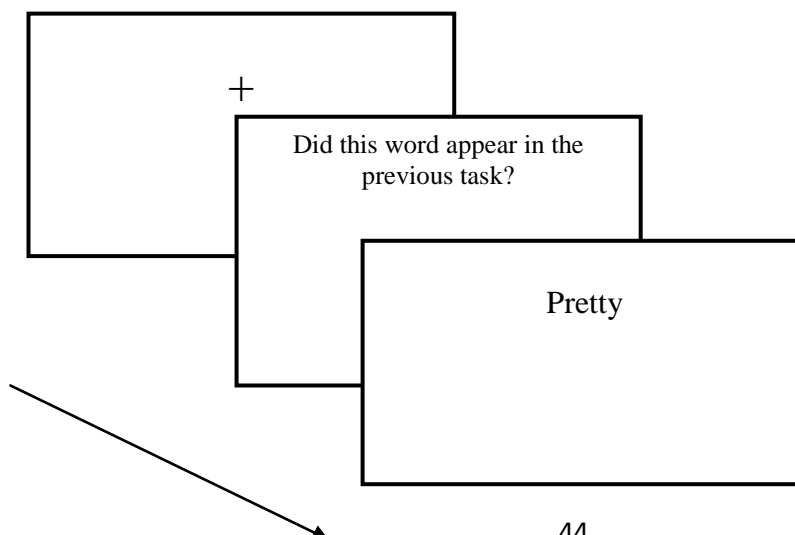
*Figure 1.1. Trial procedure in the other referent condition.*



**Test phase**

A standard surprise recognition test procedure was used. The 100 previously studied adjectives were presented along with a set of 50 lure items - a previously unseen set of 25 physical and 25 psychological trait words. Adjectives were presented individually in a pseudo-random order, subject to the same constraints that applied during the study phase. Participants were asked to decide whether or not each word had appeared in the previous task by stating either “yes” or “no”. Each word remained on the screen until a response had been made. Figure 1.2 illustrates the trial procedure.

*Figure 1.2. Trial procedure.*



## **Scoring**

The raw data was used to calculate hit rates for each of the four word types (physical self-referent, physical other-referent, psychological self-referent and psychological other-referent). These hit rates comprised the proportion of words in each of the four categories which were correctly remembered by participants. A false alarm rate was also calculated which was the proportion of physical and psychological lure words incorrectly identified by participants as having been present in the encoding condition. Corrected hit rates were then calculated which took false alarm rates into account. These were calculated by subtracting the false alarm rates for physical and psychological words from the hit rates for physical and psychological words.

## **Questionnaires**

The Private Self-consciousness Scale (PSC - Fenigstein, Scheier, & Buss, 1975) was used to measure self-awareness. The PSC assesses individual differences in levels of private self-awareness with a focus on a person's awareness of their own internal thoughts and feelings. This scale has been used extensively to assess internal thoughts, feelings and attitudes (Anderson, Bohon & Berrigan, 1996; Mittal & Balasubramanian, 1987) and has high test-retest validity (Fenigsteing, Scheier & Buss, 1975).

The Autism-spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) provides a reliable and valid measure of ASD traits, and is sensitive to ASD traits in both clinical and subclinical populations. The AQ is scored out of 50 and scores of 26 or more are considered to indicate a (potentially) clinically significant level of ASD traits (Woodbury-Smith, Robinson, Wheelwright, & Baron-Cohen, 2005).

## **Results: Experiment 1.1**

### Self-referential memory task

Preliminary analyses revealed no significant effect of task version (i.e., which of the three counterbalanced versions was completed) on performance. Thus, task version was not included as an independent variable in subsequent analyses.

Three main dependent measures were calculated: hit rate (proportion of “old” items correctly identified as “old”), false alarm rate (proportion of “new” items incorrectly identified as “old”), and corrected hit rate (hit rate minus false alarm rate). Mean hit rates, false alarm rates and corrected hit rates for each encoding condition and each word type are shown in Table 1.1.

**Table 1.1 Means and standard deviations of hit rates, false alarm rates, and corrected hit rates for each word type in each encoding condition**

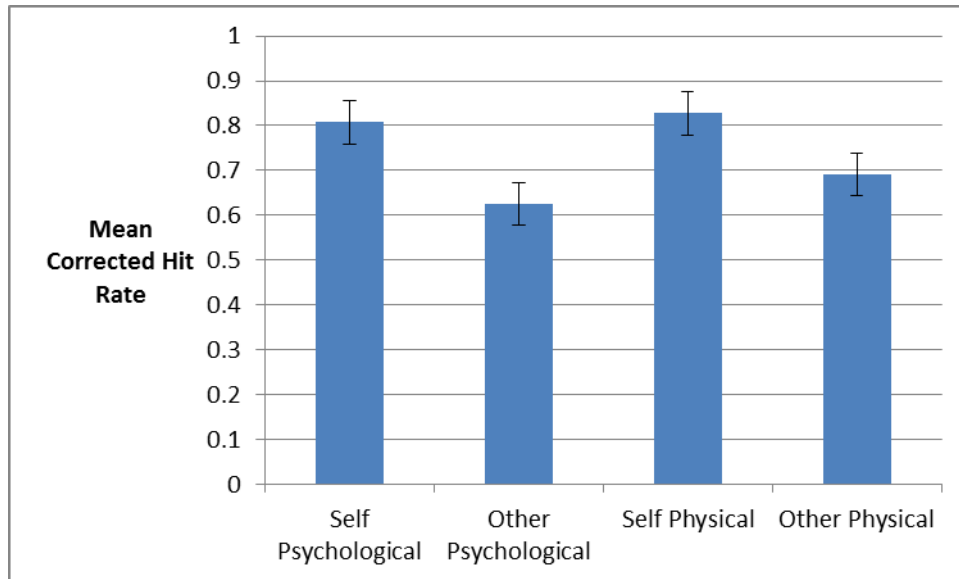
Measure	Encoding condition	Word type	<i>M</i>	<i>SD</i>
<b>Hit Rate</b>	Self	Physical	.87	.11
		Psychological	.85	.11
	Other	Physical	.74	.09
		Psychological	.67	.12
<b>False Alarm Rate</b>	N/A	Physical	.05	.03
		Psychological	.05	.03
<b>Corrected Hit Rate</b>	Self	Physical	.83	.12
		Psychological	.81	.12
	Other	Physical	.69	.09
		Psychological	.62	.12

### Corrected hit rates



Figure 1.1 shows the mean corrected hit rates for word in each of the four encoding conditions. This clearly illustrates the presence of the self-referencing effect in both the physical and the psychological domain.

*Figure 1.3. Mean proportions of words recalled in each of the four encoding conditions. Error bars represent standard error (1 SEM).*



A 2 (Referent: self, other) x 2(Word Type: physical, psychological) repeated-measures ANOVA was conducted to explore differences in corrected hit rate across the two different referents and word types. A significant main effect of Referent was revealed,  $F(1,49) = 137.27, p < .001, \eta^2 = .74$ . This reflects the fact the mean corrected hit rate for self-referent words was higher than the mean corrected hit rate for other-referent words). This confirms the existence of the predicted self-reference effect. There was also a significant effect of Word Type,  $F(1,49) = 11.66, p = .001, \eta^2 = .19$ , with the mean corrected hit rate for physical words being higher than the mean corrected hit rate for psychological words. Most significantly, there was also a significant interaction effect between Referent and Word Type,  $F(1,49) = 6.43, p = .001, \eta^2 = .12$ . The interaction between Referent and Word Type was broken down by carrying out a series

of paired-sample  $t$ -tests. For physical words, corrected hit rates for self-referent items were significantly larger than for other-referent items,  $t(49) = 9.55, p = .000$ , Cohen's  $d = 1.32$ . This was also the case with psychological words,  $t(49) = 10.03, p = .000$ , Cohen's  $d = 1.58$ . Critically, then, the size of the self-reference effect was equally large in the physical and psychological domains.

A significant difference was also revealed between corrected hit rates for other referent physical and psychological words,  $t(49) = 3.86, p < .001$ , Cohen's  $d = 0.66$ . More specifically, the mean corrected hit rate for other referent physical words was significantly higher than the mean corrected hit rate for other referent psychological words. There was no significant difference, in the self-referent domain, between hit rates for psychological and physical self-referent words  $t(49) = 1.50, p = .14$ , Cohen's  $d = 0.67$ . Thus, the interaction between Referent and Word Type was driven only by this final non-significant result.

A categorical analysis was then carried out to examine the number of individuals in each group who showed a physical or psychological self-reference effect. A general concern about only analysing the mean level of experimental task performance in each participant group is that it is unclear whether group differences are driven merely by a relatively small subset of participants. For example, in relation to the current study, it may be that only a small minority of participants showed the ownership effect.

Thus, individuals were deemed to have shown a self-referencing effect if they remembered a greater number of words in the self-referent condition than in the other-referent condition. 45/50 (90%) participants showed a self-referencing effect in the physical domain and 47/50 (94%) participants showed a self referencing effect in the psychological domain. Table 1.2 shows how many more (or less) words were recalled

by participants in the self referent as opposed to other referent domain. Figures for physical and psychological words are shown separately. It is interesting to note that, from these figures, the self-referencing effect appears to be somewhat stronger in the psychological domain; the difference between self and other referent words was more pronounced here (with more participants remembering 7 – 10 more self than other referent words) than in the physical domain. However, a chi square test revealed that the number of words recalled in the physical domain was related to the number of words recalled in the psychological domain, indicating that the two were not significantly different,  $\chi^2(1, N = 50) = 4.86, p = .03$ .

*Table 1.2:breakdown of categorical analysis.*

	Domain	Number of words recalled in Self-referent condition compared to other-referent condition						
		-10 - 7	- 6 - 4	-3 - 1	0	+ 1- 3	+4 - 6	+ 7-10
No. of participants	Physical	0	0	3	2	21	22	2
No. of participants	Psychological	0	0	2	1	15	17	15

### **Relation between self-referential memory, and measures of self-awareness and autism-like traits**

All participants obtained scores on the AQ ( $M = 13.52, SD = 6.39, Range: 2 - 24$ ) that fell below the cut-off for clinically significant levels of ASD traits ( $< 26$  points; Woodbury-Smith, Robinson, Wheelwright, & Baron-Cohen, 2005).

To gain a measure of the strength and size of the self-reference effect in each domain (physical/psychological), difference scores between corrected hit rate for self-referent items and corrected hit rate for other-referent items were calculated for each participant. The difference score for physical words, which quantified the “physical self-reference effect”, was calculated by subtracting the corrected hit rate for other-referent physical words from the corrected hit rate for self-referent physical words.

The difference score for psychological words, which quantified the “psychological self-reference effect” was calculated by subtracting the corrected hit rate for other-referent psychological words from the corrected hit rate for self-referent psychological words. Thus, in each domain, the larger the resulting value, the greater the self-reference effect. The mean difference scores for physical and psychological words were .14 ( $SD = .10$ ) and .18 ( $SD = .13$ ), respectively. A significant correlation was found between difference scores for physical words and difference scores for psychological words,  $r = .40$ ,  $p = .01$ .

No significant correlation was found between difference scores for psychological words and scores on the PSC,  $r = -.04$ ,  $p = .76$ , or between difference scores for physical words and scores on the PSC,  $r = .14$ ,  $p = .34$ . There was no significant correlation between AQ scores and difference scores for physical words,  $r = .15$ ,  $p = .31$ . However, there was a significant correlation between AQ scores and difference scores for psychological words,  $r = .37$ ,  $p = .01$ . A Fisher’s  $z$  test revealed that there was no significant difference between these two correlations,  $z = -1.15$ ,  $p = .13$ .

## **Discussion**

The purpose of Experiment one was firstly to ascertain whether or not the self-reference effect observed in previous studies (Kuiper & Derry, 1982; Symons & Johnson, 1997, Yiend, Mackintosh & Mathews, 2003) was present in both the physical and psychological domains. It was also intended to investigate the link between levels of self-reported self-awareness and the strength of the self-reference effect and between levels of autism-like traits and the strength of the self-reference effect.

As expected, the self-reference effect was present in both domains. This is in line with the results of earlier studies which have repeatedly shown that adjectives, such as ‘clever’ are recalled with a greater degree of accuracy when related to the self than when related to a close or non-close other (Symons & Johnson. 1997). This suggests that this task does reliably show the expected self-reference effect in typical populations. This is in line with the idea that, amongst typically developing individuals, the self has both physical and psychological components which develop in parallel at least to some extent (Broughton, 1978), meaning that it would be expected that phenomena such as the self-reference effect would show robust effects across both domains.

It is interesting that this effect was observed when a non-close other was being considered in the other referencing condition. It would be reasonable to expect that the physical self-reference effect would be reduced in this particular case, since it is likely that most participants would have a more detailed knowledge of a celebrity’s physical appearance than of their personality. The fact that this reduction did not occur may be indicative of the strength of this effect. It would be interesting to repeat this task with a close other (such as a long-standing friend or a family member) in the other referencing condition.

Data from the AQ and the Private Self-Consciousness Scale was included partly to assess whether or not a difficulty expressing and describing one’s own emotions (and therefore a potentially impaired psychological self-concept) was linked with the strength of self-reference effect displayed, and partly to ascertain whether or not there was one common factor underlying performance on both the questionnaire measures. Results here were mixed. Scores on the private self-consciousness scale were not linked with

the strength of the self-reference effect in either domain. However, scores on the AQ did correlate with difference scores in the psychological domain. These results suggest that the strength of the psychological self-referencing effect present is related to the level of sub-clinical autism-like traits present. This association was not present in the physical domain. These findings are in line with the large body of research which suggests that the physical and psychological aspects of the self-concept are dissociable from one another. They develop relatively separately in infancy and early childhood and appear to maintain this separation into adulthood. Levels of autism like traits seem to have little real bearing on how developed one's physical sense of self is, but they do influence the development of one's psychological sense of self.

What is perhaps more interesting, are the potential ramifications of this result for the study of autism spectrum disorder. As levels of autism-like traits were correlated with one dimension of the self, but not the other, this lends further support to the idea that some parts of the self-concept are impaired in autism spectrum disorder, while others remain intact. More specifically, levels of autism like traits were related to the strength of the psychological self-concept, but not the physical self-concept. This is in line with the evidence discussed in the general introduction which suggests that the physical self-concept is intact in ASD, while the psychological self-concept is impaired. The following two chapters use similar tasks to explore self-referencing in adults and primary school age children with a diagnosis of ASD.

## Chapter Two: Self Referencing in Autism Spectrum Disorders

In the previous chapter the self reference effect in the physical and psychological domains was investigated in a population of typically developing adults. It was found that the self-reference effect was present in both domains. This suggests that, as expected, typically developing adults have a well-developed physical and psychological self-concept. More interestingly, an association was also found between levels of sub-clinical autism-like traits and the strength of the self-referencing effect in the psychological domain, but not the physical domain. In individuals with a clinical diagnosis of ASD, this trend is likely to be exacerbated. We would predict that the psychological self-concept would be impaired in ASD, whilst the physical self-concept remains relatively intact. This chapter outlines two experiments which test the strength of the physical and psychological self-concepts in ASD using self-referencing paradigms.

A number of previous studies have examined self-referencing in individuals with ASD. Toichi and Kamio (2002) investigated the SRE in ASD by presenting participants with personality trait adjectives in the context of questions. The goal of this study was to examine the self-referencing effect in relation to levels of cognitive processing. As such, questions asked elicited either surface level processing (e.g. “does the word rhyme with...?”), semantic level processing (e.g. “is the meaning of the word similar to...?”) or a self-reference effect (e.g. “does the word describe you?”). Participants without ASD remembered more of the words in the self-referencing condition than in the other two conditions, while participants with ASD remembered equal numbers of words in the self-referencing and semantic conditions and there was a significant interaction

effect between group and encoding condition. Importantly, this study included no other-referencing condition and, as such, did not directly compare self-referent and other-referent processing.

This work was built on by Lombardo, Barnes, Wheelwright and Baron-Cohen (2007) who asked participants whether a number of trait adjectives could be used to describe either themselves, their best friend, or a fictional character (in this case, Harry Potter). Typically developing comparison participants, when presented with a standard recognition task, remembered a greater number of words from the self-referencing condition than from the best friend and Harry Potter conditions, as did participants with autism. However, the differences in the numbers of words recalled in each of the three conditions were reduced in autism, and, in particular, the difference between the self and Harry Potter conditions was very small, implying that the self-reference effect is reduced in autism. Henderson et al. (2009) partially replicated Lombardo's study with children rather than adults. The close other ('best friend') condition was not included in this study, but the non-close other ('Harry Potter') condition was present. In children, the performance of the group with ASD differed drastically from the performance of the controls as the children with ASD displayed an almost complete absence of the self-referencing effect.

The two experiments presented in this chapter employ a similar paradigm to the one used in chapter one to examine self-referencing in adults with ASD. In experiment 2.1, a group of participants with ASD and a group of age-, gender-, and IQ-matched controls completed the same experimental tasks. Experiment 2.2 took the form of an attempt to conduct a study that was more similar in structure to that of Lombardo, Barnes,



Wheelwright & Baron-Cohen (2007). This was to allow a direct comparison between our paradigm and theirs.

It is predicted that people with ASD will show a difference in self-referencing style in the physical vs. psychological condition. More specifically, it is thought that they will show a reduced self-referencing effect in the psychological domain. However, the physical self referencing effect may still be present in this group since it may be independent of the existence of an intact psychological self-concept.

## **Method: Experiment 2.1**

### **General**

All participants completed a memory task (described below) and a questionnaire designed to measure self-awareness (the Private Self-Consciousness Scale; Fenigstein, Schier, & Buss, 1975). All participants completed both parts of the study in one testing session which took approximately an hour.

### **Participants**

Thirty-two participants took part in the study, 16 of whom (3 female) had a current diagnosis of autism spectrum disorder ( $n = 2$ ) or Asperger's disorder ( $n = 14$ ). All diagnoses were made according to standard criteria (American Psychiatric Association, 2000; World Health Organisation, 1992). All documented diagnostic information was checked thoroughly.

The 18 typically developing (TD) participants (5 female) had no current or past history of psychological disorders (as defined by DSM IV criteria). The Wechsler Abbreviated

Scale of Intelligence (WASI; Psychological Corporation, 1999) was administered to all participants and used to ensure that the two groups of participants were closely matched in terms of verbal and non-verbal ability. The groups were also matched for age and gender. Group differences in age and IQ were negligible (See table 2.1 for participant characteristics and group comparisons).

**Table 2.1: Mean ages and performance IQ, verbal IQ and full scale IQ scores for typically developing participants and participants with ASD. Group differences in Age and IQ are also shown.**

	ASD		TD		Group Comparisons		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>	Cohen's <i>d</i>
<b>Age</b>	31.33	9.90	34.92	14.79	.73	.48	-0.29
<b>PIQ</b>	112.53	14.21	116.81	10.70	.94	.36	-0.34
<b>VIQ</b>	110.19	13.99	112.81	13.95	.65	.52	-0.19
<b>FSIQ</b>	112.31	14.49	116.75	12.33	1.09	.30	-0.33

The severity and type of ASD features amongst participants in the ASD group and the presence of ASD-like features in participants in the control group were assessed using the Autism-spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), which was completed by the participants themselves. The AQ is a 50-item questionnaire that is suitable for administration with adults whose intelligence is within the average or above-average range (where 'average' is defined as being between 85 and 115), which provides a quantitative index of self-reported ASD traits. Fifteen out of 16 comparison participants scored below the ASD cut-offs on the AQ. One participant scored above the ASD cut-offs. As a precaution, all analyses were run with this participant excluded and this had no significant effect on results. Therefore, all

reported analyses included all participants. Fourteen out of 16 participants in the ASD group scored above the cut-offs for ASD on the AQ. In addition, 14/16 participants with ASD also completed the Autism Diagnostic Observation Schedule – Generic (ADOS; Lord et al., 2000). The ADOS is a semi-structured, standardized assessment of social interaction, communication, play, and imaginative use of materials, and is frequently used in the diagnostic assessment of ASD. Two participants declined to complete the ADOS, but scored above the cut-offs for ASD on the AQ. Those participants who scored below the ASD cut-offs on the AQ scored above the ASD cut-offs on the ADOS. Therefore, consistent with their formal diagnoses, all participants with ASD scored above the ASD cut-off on at least one out of the two measures employed in the current study, and the majority scored above the ASD cut-off on both measures. All participants gave informed, written consent before taking part and all received either compensation or course credit for their time.

## **Materials and Procedure**

### **Selection of stimuli and task design**

150 trait adjectives, half of which could be used to describe personality (psychological) characteristics, and, half of which could be used to describe physical characteristics, were selected for use in the study. The personality trait adjectives and physical trait adjectives were selected from validated lists compiled by Anderson (1968) which included ratings for ‘meaningfulness’ (how well the word is understood) and ‘likability’ (how positive the word is judged as being). Words selected for inclusion in the study were ‘matched’ on these two measures so that enhanced or impaired performance on one counterbalanced version of the task or on one particular word type would not be due to differences in the meaningfulness or likability of that group of words as a whole. A MANOVA revealed that meaningfulness,  $F(1,149) = .16, p = .69, \eta^2 = 0.01$ , and

likability,  $F(1,149) = 0.26$ ,  $p = .61$ ,  $\eta^2 = .002$ , did not differ significantly between the different conditions.

Three counterbalanced versions of the task were created. Each version comprised three sub-lists of 50 adjectives, namely 50 adjectives to be used in the self-referencing condition, 50 to be used in the other referencing condition and 50 to be used as lures. Half of all the words used were physical trait adjectives and half were psychological trait adjectives. The stimuli used here were identical to those used in experiment 1.1.

The sub-lists were rotated through the counterbalanced versions, such that each sub-list appeared as self-referential target items in one version, other-referential target items in one version, and lure items in one version.

### **Encoding phase**

During the encoding phase, 100 trait adjectives were presented, half in the self-referencing condition and half in the other referencing condition. In the ‘self-referent’ condition, participants assessed whether or not the adjective was representative of them. In the ‘other referent’ condition, participants judged whether or not the adjective was representative of a gender-matched celebrity (Simon Cowell for male participants and Cheryl Cole for female participants). Each adjective was presented, following a question designed to elicit either self-referential or other-referential processing, for example ‘*Does this word describe Cheryl Cole?*’ ‘*Pretty*’. The structure of the questions was identical between the self- and other-referent conditions.

Adjectives were presented in a pseudo-random order, subject to the constraint that no more than four physical or four psychological trait adjectives appeared consecutively, and no more than four self- or other-referential questions were presented consecutively.

### **Test phase**

A standard surprise recognition test procedure was used. The 50 previously seen adjectives were presented along with a set of lures; a previously unseen set of 25 physical and 25 psychological trait adjectives. Stimuli were presented individually in a pseudo-random order, subject to the constraints detailed above. Participants were asked to state whether or not each word had appeared in the previous task.

### **Scoring**

The raw data was used to calculate hit rates for each of the four word types (physical self-referent, physical other-referent, psychological self-referent and psychological other-referent). These hit rates comprised the proportion of words in each of the four categories which were correctly remembered by participants. A false alarm rate was also calculated which was the proportion of physical and psychological lure words incorrectly identified by participants as having been present in the encoding condition. Corrected hit rates were then calculated which took false alarm rates into account. These were calculated by subtracting the false alarm rates for physical and psychological words from the hit rates for physical and psychological words.

### **Measures of Self-Awareness**

Self-awareness was measured using the Private Self-Consciousness Scale (Fenigstein, Scheier, & Buss, 1975). The Private Self-Consciousness Scale assesses individual differences in levels of private self-awareness with a focus on a person's awareness of their own internal thoughts feelings and physical sensations. This scale has been used extensively to assess internal thoughts, feelings and attitudes (Anderson, Bohon, & Berrigan, 1996) (Mittal & Balasubramanian, 1987) and has a high test-retest validity (Fenigsteing, Scheier, & Buss, 1975).

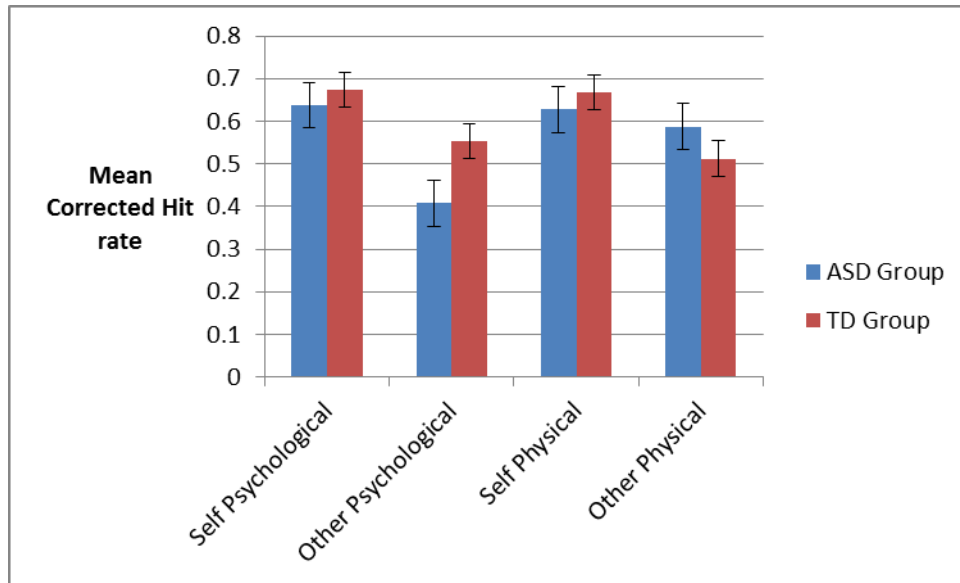
## Results: Experiment 2.1

The raw data was used to calculate hit rates, false alarm rates and corrected hit rates. Means and standard deviations for these are shown for the ASD and comparison groups in the table and graph below.

**Table 2.2 Means and Standard Deviations of false alarm rates, hit rates and corrected hit rates for the ASD and Comparison groups.**

Measure	Word Type	Referent	ASD Group		TD Group	
			<i>M</i>	<i>sd</i>	<i>M</i>	<i>sd</i>
False Alarm Rate	Physical	N/A	.11	.10	.15	.09
	Psychological	N/A	.14	.12	.16	.09
Hit Rate	Physical	Self	.77	.19	.83	.10
	Physical	Other	.73	.19	.68	.13
	Psychological	Self	.78	.20	.84	.12
	Psychological	Other	.55	.19	.72	.09
Corrected Hit Rate	Physical	Self	.63	.26	.67	.14
	Physical	Other	.59	.25	.51	.17
	Psychological	Self	.64	.27	.68	.15
	Psychological	Other	.41	.24	.55	.12

Figure 2.1 Corrected hit rate for TD and ASD groups. Error bars represent one SEM.



### Analysis of Corrected Hit Rates

A repeated measures ANOVA, with a between-subjects factor of group and within-subjects factor of Adjective Type (physical and psychological) and Referent (self and other), was then carried out with corrected hit rates as the dependent variable.

There was a highly significant main effect of Referent,  $F(1, 29) = 52.27, p < .001, \eta^2 = .64$ . This is due to the fact that the mean corrected hit rate for self-referent words was greater than the mean corrected hit rate for other referent words. There was no significant main effect of Adjective Type  $F(1,29) = 1.73, p = .20, \eta^2 = .06$ . There was also no significant main effect of Group,  $F(1,29) = 0.33, p = .57, \eta^2 = .01$ . This shows that there was no difference in general memory performance between the two groups.

A significant interaction effect between Adjective Type and Group,  $F(1,29) = 6.35, p = .02, \eta^2 = .18$  was revealed. A series of paired sample  $t$ -tests showed non-significant differences between corrected hit rates for self-referent physical and psychological words,  $t(15) = .29, p = .78$ , and between corrected hit rates for other-referent physical and psychological words,  $t(15) = 1.32, p = .21$ , among participants in the TD group.

Participants in the ASD group also showed a non-significant difference between

corrected hit rates for self-referent psychological and physical words,  $t(15) = .28, p = .79$ . However, a significant difference was found between corrected hit rates for other referent psychological and physical words,  $t(15) = 3.72, p = .02$ , Cohen's  $d = 0.75$  in this group. This reflects the fact that mean for other referent physical words was higher than the mean from other referent psychological words.

There is a significant interaction effect between Adjective Type and Referent,  $F(1,29) = 7.56, p = .01, \eta^2 = .21$ . It was demonstrated, using paired t-tests, that significant differences in corrected hit rates existed between other-referent psychological and other-referent physical words,  $t(31) = 2.04, p = 0.05$ , Cohen's  $d = 0.36$ , between self and other referent psychological words,  $t(31) = 6.62, p < 0.01$  Cohen's  $d = 0.89$ , and between self and other referent physical words,  $t(31) = .40, p < 0.69$ , Cohen's  $d = 0.51$ . The difference in corrected hit rates between self-referent psychological and physical words was non-significant,  $t(31) = 4.245, p = .30$ . There is also a highly significant three-way interaction between Adjective Type, Referent and Group,  $F(1,29) = 14.92, p < .01, \eta^2 = .34$ . The interaction between Referent and Group was non-significant,  $F(1,29) = 0.03, p = .87, \eta^2 = .001$ .

A categorical analysis was then carried out to examine the number of individuals in each group who showed a physical or psychological self-reference effect. Individuals were deemed to have shown a self-referencing effect if they remembered a greater number of words in the self-referent condition than in the other-referent condition. This analysis revealed that, in the TD group, 15 out of the 16 participants (94%) showed a self-referencing effect in the physical domain, with the remaining participant remembering equal numbers of words in the self and other referent condition. None of the participants performed at ceiling in either condition. In the psychological domain,



14 out of the 16 TD participants (88%) showed a self-referencing effect. Again, none of the participants performed at ceiling.

Amongst the ASD group, only 9 out of the 16 participants (56%) showed a self referencing effect in the physical domain, with three participants remembering equal numbers of words in both conditions (although performance was not at ceiling). This suggests a reduced self-referencing effect. In the psychological domain, 14 out of the 16 participants (88%) showed a self-referencing effect, with one participant remembering equal numbers of self and other referent words (again, performance was below ceiling). When the ASD and TD groups were compared, a chi squared test demonstrated that performance of the two groups in the physical domain was significantly different,  $\chi^2(1, N = 16) = 6.0, p = .02, \phi = .04$ . In the psychological domain, the opposite pattern of results was seen,  $\chi^2(1, N = 16) = 0.0, p = 1.0, \phi = .1.0$ . Table 2.3 shows a breakdown of the categorical analysis, detailing how many more (or less) words participants remembered in the self referent condition compared to the other referent condition.

*Table 2.3. Breakdown of Categorical Analysis*

		Number of words recalled in self-referent condition compared to other referent condition						
		-7 - 10	-6 - 4	- 1 - 3	0	+1 - 3	+4 – 6	+7 or more
Number. of ASD participants	Physical	0	2	3	2	7	1	1
	Psychological	0	0	1	1	2	5	7
Number. of TD participants	Physical	0	0	0	1	6	7	2
	Psychological	0	1	1	0	6	7	1

## Questionnaire Data

### Questionnaires and Scoring

Participants' scores on the AQ and Private Self-consciousness Scale are shown in table 2.3. There was a significant difference in AQ scores between the ASD and comparison

groups and no significant difference for PSC scores between the two groups (see table 2.3 for statistics).

**Table 2.4. Means and Standard Deviations of scores on the AQ and the Private Self-Consciousness Scale. Group comparisons are also shown.**

	ASD Group				TD Group				Group Comparisons		
	<i>M</i>	<i>sd</i>	<i>Min</i>	<i>Max</i>	<i>M</i>	<i>sd</i>	<i>Min</i>	<i>Max</i>	<i>t</i>	<i>p</i>	Cohen's <i>d</i>
<b>AQ</b>	34.63	9.90	14	46	14.56	5.60	5	24	6.71	.001	2.49
<b>PSC</b>	22.19	4.23	15	30	19.25	5.59	10	28	1.67	.12	0.59

### Correlation Analyses

Difference scores were calculated by subtracting other referent hit rates from self-referent hit rates in both the physical and psychological domains. The mean difference score for physical trait adjectives amongst participants in the ASD group was .04 (SD = .15). In the TD group, this figure was .16 (SD = .08), suggesting that, for physical words, the self-referencing effect was stronger within the TD group.

For psychological trait adjectives, the mean difference score in the ASD group was .23 (SD = .16) and in the TD group, it was .12 (SD = .12). This suggests that the self-referencing effect for psychological words was much stronger in the group with ASD. The ASD group also showed a stronger self-referencing effect overall for psychological words than for physical words, while this trend was reversed, and not as dramatic, in the TD group. It is unclear from the current experiment, how much of the enhanced performance of the group with ASD was due to a deficit in other referent processing, rather than an increase in self-referent processing per se.

It should also be noted that the difference scores obtained in the TD group were similar to those obtained in the physical domain in experiment 1.1 (physical difference score = .14,  $SD = .10$ , psychological difference score = .18,  $SD = .13$ ). This suggests that the smaller sample employed here has replicated the trend observed in the larger sample in experiment 1.1.

In the TD group there were no significant correlations between scores on the Private Self Consciousness Scale and either physical,  $r = .18$ ,  $p = .50$ , or psychological difference scores,  $r = .10$ ,  $p = .70$ . Similarly, there were no significant correlations between performance on the AQ and either physical,  $r = .27$ ,  $p = .31$ , or psychological,  $r = .37$ ,  $p = .16$  difference scores. Although, the correlation between AQ scores and psychological difference scores here is non-significant, the  $r$  value generated (.37) is identical to that seen in the significant correlation in experiment 1.1. This implies that the non-significant result here is merely a consequence of the lower statistical power which necessarily occurs when smaller samples are used. The correlation between physical and psychological difference scores was non-significant,  $r = .26$ ,  $p = .34$ .

In the ASD group, there were no significant correlations between scores on the private self-consciousness scale and either physical,  $r = .10$ ,  $p = .71$ , or psychological,  $r = .01$ ,  $p = .98$ , difference scores. There was no significant correlation between scores on the AQ and psychological differences scores,  $r = .31$ ,  $p = .24$ , or between AQ scores and physical difference scores,  $r = -.18$ ,  $p = .50$ . The correlation between AQ scores and psychological difference scores was similar to that seen in the TD groups in both the current experiment and experiment 1.1. As this correlation was significant in experiment 1.1, its non-significance here may be a consequence of the small sample size employed. There were no significant correlations between scores on the AQ and Private

Self-Consciousness Scale,  $r = -.09$ ,  $p = .73$ . The correlation between physical and psychological difference scores was non-significant,  $r = .26$ ,  $p = .34$ .

### **Discussion: Experiment 2.1**

The purpose of experiment 2.1 was to investigate the presence and strength of self-referencing effects in the physical and psychological domains in a population of adults with ASD. A secondary purpose was to examine the relationship between the type of self-referencing effect present and levels of self-reported self-awareness and autism like traits.

The results from the TD group were as expected. The self-referencing effect was present in both the physical and the psychological domains. This establishes the paradigm used as one which reliably demonstrates the self-referencing effect as these results are in line with those presented in chapter one. The lack of significant correlations seen between questionnaire measures in the TD group is likely to be due to the small sample size; the  $r$  value observed for the correlation between psychological difference scores and AQ scores was identical to that observed for the significant correlation in experiment 1.1. This suggests that the results of the TD group did successfully replicate those observed in experiment 1.1.

In the ASD group, when the raw data regarding numbers of words recalled is considered independently of the magnitude of self-referencing effects, adjective type had a significant effect on results with physical words being better recalled than psychological words in general, suggesting a focus on the physical rather than the psychological. This is in keeping with the evidence from earlier studies which suggests that the

psychological self-concept is impaired in ASD (Ben Shalom, Mostofsky, et al, 2006), but the physical self-concept is relatively intact (Lind & Bowler, 2009; Williams & Happe, 2009). However, the physical self-referencing effect in the current study was somewhat reduced when compared to the TD group which does not support our initial hypothesis that the physical self-reference effect would be intact in the ASD group.

Participants with ASD displayed the self-referencing effect in both the physical and the psychological domains, however, as stated above, self-referencing in the physical domain appeared to be somewhat reduced when compared to the TD group, while self-referencing in the psychological domain seemed to be rather strikingly enhanced.

The presence of a reduced self-referencing effect in the physical domain amongst participants with ASD is in line with our initial hypothesis that the SRE in general is likely to be diminished amongst participants with ASD. These results are also in line with the performance on self-referencing tasks observed by Toichi and Kamio (2002) and Lombardo et al (2007). The enhanced SRE seen in the psychological domain is somewhat unusual and seems to go against the evidence of previous research.

However it is notable that this enhanced psychological self-referencing effect was driven by a strikingly low level of recall of other-referent psychological traits, rather than an enhanced level of recall of self-referent psychological traits. Simulation Theory (Goldman, 1992) suggests that we use an understanding of our own thoughts and feelings as a model for the understanding of the thoughts and feelings of others. The results here are in line with Simulation Theory in that Simulation theory would predict a non-diminished psychological SRE. The lack of other-referent psychological processing may be indicative of a lack of understanding of the thoughts and feelings of the self and therefore of an impairment in the psychological self-concept. This idea is in

line with the plethora of evidence which exists to suggest that people with ASD experience difficulties understanding the psychological and emotional traits of others (Carpenter, Pennington & Rogers, 2001). When the results of the self-referent condition are considered independently of the results from the other-referent condition, participants with ASD recalled less psychological adjectives than their typically developing peers and an almost comparable number of physical trait adjectives. This again suggests an impairment of the psychological self-concept.

The presence of an SRE at all in the psychological domain may be due in part to individuals with ASD learning their own psychological traits by rote (Hill, Berthoz & Frith, 2004) as has been seen in previous studies. For example, Lee, and Hobson (1998) conducted the self-understanding interview (Damon & Hart, 1982) with a group of children with ASD and found that, although the number of psychological statements made by these children was not reduced when compared to typically developing children, the type of psychological statements in the ASD group was limited and had a learned quality.

Our results remain somewhat unusual given the findings of earlier studies in this area which have suggested that the self-referencing effect in ASD is almost entirely absent (Toichi & Kamio, 2002). However, these null findings may be partly due to the particular methodologies employed in earlier studies. Toichi and Kamio (2002) inferred an absence of the self-referencing effect from a study which compared performance in a self-referent condition to performance in a number of conditions designed to examine the levels of processing effect. As their study did not include an other referent condition, it is hard to compare the pattern of self-referencing displayed there to that seen in the current study.

Given our somewhat unusual pattern of results when compared to results from earlier studies, it was decided to carry out a direct replication of Lombardo, Barnes, Wheelwright & Baron-Cohen (2007) in order to more directly compare our results to theirs, and to ascertain whether our results were due to a quirk of the methodology employed (in which case we would replicate Lombardo et al) or due to a sampling issue (in which case, we would not replicate Lombardo et al). This replication formed Experiment 2.2.

### **Experiment 2.2: Method**

Experiment 2.2 was intended to be a replication of Lombardo, Barnes, Wheelwright & Baron-Cohen (2007) and as such the method followed Lombardo as closely as possible and used comparable stimuli.

#### **Participants and Design**

The study used a repeated measures design with all participants viewing all stimuli and all conditions (Self-referent, close other-referent, non-close other referent and semantic conditions). Thirty-two participants took part in the study, 16 of whom (3 female) had a current diagnosis of autism spectrum disorder or Asperger's disorder ( $n = 12$ ). All diagnoses were made according to standard criteria (American Psychiatric Association, 2000; World Health Organisation, 1992). All documented diagnostic information was checked thoroughly.

The 16 control participants (4 female) had no current or past history of psychological disorders (as defined by DSM IV criteria). The Wechsler Abbreviated Scale of Intelligence (WASI; Psychological Corporation, 1999) was administered to all participants and used to ensure that the two groups of participants were closely matched in terms of verbal and non-verbal ability. The groups were also matched as far as possible for age and gender. Group comparisons are shown in table 2.4. (See table 2.4 for participant characteristics).

**Table 2.5: Participant Characteristics and Group Comparisons.**

	ASD Group		TD Group		Group Comparisons		
	<i>M</i>	<i>sd</i>	<i>M</i>	<i>sd</i>	<i>t</i>	<i>p</i>	Cohen's <i>d</i>
<b>Age</b>	29.27	10.87	31.68	13.77	.60	.56	-0.19
<b>VIQ</b>	111.94	15.40	113.06	12.23	.22	.83	-0.08
<b>PIQ</b>	114.93	11.76	113.25	11.04	.49	.49	0.15
<b>FSIQ</b>	114.38	14.56	114.81	10.62	.10	.92	-0.03

The severity and type of ASD features amongst participants in the ASD group and the presence of ASD-like features in participants in the control group were assessed using the methods detailed in Experiment 2.1. 14 out of 16 participants completed the ADOS. 2 participants declined to complete the ADOS, but scored above the cut-offs for ASD on the AQ. Two participants with ASD scored below the cut-offs for ASD on the AQ, but above the cut-offs for ASD on the ADOS. Consistent with their formal diagnoses, all participants with ASD scored above the ASD cut-off on at least one out of the two measures employed in the current study. All participants gave informed, written consent before taking part and all received either compensation or course credit for their time.



## **Stimuli and Materials**

The stimulus items used comprised a set of 150 adjectives commonly used to describe personality traits. These items were divided up into four lists of 30 items each with an additional fifth list of 30 words used as ‘lures’ in all versions of the task. Words in each list were matched for levels of meaningfulness and likeability. A standard counterbalancing procedure was used to create four different versions of the task so that each word list was used in each condition of the task for a quarter of the participants. A MANOVA was conducted and revealed that there were no significant differences between the word lists in terms of meaningfulness,  $F(4, 235) = .002, p = 1.0, \eta^2 = .00$ , and likability,  $F(4, 235) = .27, p = .90, \eta^2 = .005$ .

### **Procedure.**

#### **Encoding phase**

During the encoding phase, 120 trait adjectives were presented, equally divided between the self referencing, close other referencing, non- close other referencing and semantic encoding conditions. In the ‘self-referent’ condition, participants assessed whether or not the adjective was representative of them. In the ‘close other referent’ and ‘non-close other referent’ conditions, participants judged whether or not the adjective was representative their best friend or the fictional character, Harry Potter, respectively. Finally, in the semantic encoding condition, participants made a judgement regarding how many syllables a word contained. Each adjective was presented following a question designed to elicit either self-referential processing, other-referential processing or semantic processing, for example ‘*Does this word describe your best friend?*’ ‘*clever*’. The structure of the questions was identical between the self- and other-

referent conditions. In addition, participants' familiarity with Harry Potter was assessed before testing. This was done by asking how many Harry Potter books or films they had read or seen. For one participant, the character of Frodo from '*The Lord of the Rings*' was used in the non-close other condition instead of Harry Potter due to the participant's lack of familiarity with the Harry Potter franchise. Adjectives were presented in a pseudo-random order, subject to the constraint that no more than three adjectives from any one condition were presented consecutively.

### **Test phase**

A standard surprise recognition test procedure was used. The 120 previously seen adjectives were presented along with a set of lures; a previously unseen set of 30 adjectives. Adjectives were presented individually in a pseudo-random order, subject to the constraints detailed above. Participants were asked to state whether or not each word had appeared in the previous task.

### **Scoring**

The scoring procedure was identical to that employed in Experiment 2.1.

### **Measures of Self-Awareness**

The measures of self-awareness used were identical to those used in Experiment 2.1.

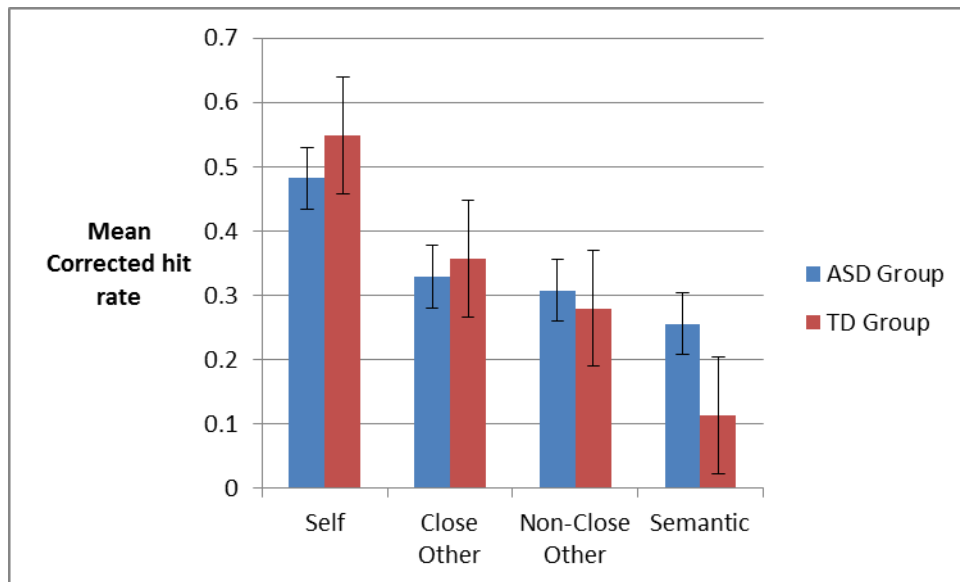
## **Results: Experiment 2.2**

Key measures to be analysed in this results section are corrected hit rates for the four different conditions (self-referent, close other referent, non-close other referent and semantic) and effects of group (ASD, TD) on performance. The table below shows the mean hit rates, corrected hit rates and false alarm rates for participants in the ASD and TD groups. Corrected hit rates for each group are presented in figure 2.2.

**Table 2.6: Means and Standard Deviations of hit rates, corrected hit rates and false alarm rates in each of the four conditions, according to participant group**

Measure	Condition	ASD Group		TD Group	
		<i>M</i>	<i>sd</i>	<i>M</i>	<i>sd</i>
Hit Rate	Self	.75	.19	.79	.15
	Close Other	.59	.20	.60	.17
	Non-close	.57	.22	.53	.12
	Other				
False Alarm Rate	Semantic	.46	.24	.36	.17
	N/A	.26	.08	.25	.11
Corrected Hit Rate	Self	.48	.22	.55	.19
	Close Other	.33	.24	.36	.19
	Non-Close	.31	.23	.28	.16
	Other				
	Semantic	.20	.23	.11	.15

*Figure 2.2 Corrected hit rates for ASD and TD groups. Error bars represent standard error (1 SEM).*



### Analysis of corrected hit rates

A repeated measures ANOVA was carried out to assess the effect of Condition (self referent/ other referent/ non-close other referent/semantic) and Group (ASD/TD) on

corrected hit rate. A significant main effect of Condition was revealed,  $F(3,90) = 37.82$ ,  $p < .001$ ,  $\eta^2 = .56$ . This reflects the fact the mean corrected hit rate for self-referent words ( $M = .51$ ,  $SD = .21$ ) was higher than the mean corrected hit rate for close other-referent words ( $M = .34$ ,  $SD = .21$ ), non-close other referent words ( $M = .29$ ,  $SD = .19$ ) and words in the semantic condition ( $M = .16$ ,  $SD = .19$ ). This again confirms the existence of the expected self-referencing effect. There was no significant main effect of Group on corrected hit rate,  $F(1,30) = 0.01$ ,  $p = .94$ ,  $\eta^2 = .01$ . This suggests that there were no differences in general memory performance between the two groups. There was no significant interaction effect between Group and Condition,  $F(3,90) = 1.92$ ,  $p = .13$ ,  $\eta^2 = .06$ . Figure 2.2 illustrates clearly that both groups showed the same overall pattern of results.

Categorical analyses were then carried out to determine how many participants in each of the two groups showed the self-reference effect. In both the TD and ASD groups, 14 out of 16 participants (87.5%) showed the self-reference effect when corrected hit rates for the close other condition were subtracted from corrected hit rates for the self condition. However, when corrected hit rates for close other and non-close other referent conditions were compared, 11 out of 16 participants (68.75%) in the TD group remembered more words in the close other referent condition than in the non-close other referent condition, but, in the ASD group, only 5 out of the 16 (31.25%) participants remembered more words in the close other referent condition than the non-close other referent condition. A chi squared test revealed that performance between the two groups was significantly different,  $\chi^2(1, n = 16) = 4.5$ ,  $p = .03$ ,  $\Phi = .38$ . When corrected hit rates for the non-close other and semantic conditions were compared, 13 out of 16 (81.25%) TD participants remembered more words in the non-close other condition than in the semantic condition and 12 out of 16 participants (75.0%) with ASD remembered more

words in the non-close other condition than in the semantic condition. A chi squared test demonstrated that performance by the ASD and TD groups was not significantly different,  $\chi^2 (1, n = 16) = .18, p = .67, \Phi = .08$ . Table 2.7 shows a breakdown of the categorical analysis, detailing the degree of difference in performance between different categories.

**Table 2.7. Breakdown of Categorical Analysis**

		No. of words remembered in first category as opposed to second category						
		-10 - 7	-6 - 4	-3 - 1	0	+1 -3	+4 - 6	+7 or more
No. of Participants	Self Vs. Close other (ASD)	0	0	1	1	7	2	5
	Self Vs. Close Other (TD)	1	0	0	1	2	4	8
	Close other Vs. non-close other (ASD)	5	0	2	0	2	4	3
	Close other Vs. non-close other (TD)	0	0	3	2	6	2	3
	Non-close other Vs. Semantic (ASD)	0	0	3	0	7	2	4
	Non-close other Vs. Semantic (TD)	0	0	3	1	5	1	6

## Questionnaire Data

### Questionnaires and Scoring.

Participants' scores on the Private Self-consciousness Scale and the Autism Spectrum Quotient (AQ) are shown in Table 2.6.

**Table 2.8: Means and Standard Deviations of scores on the Private Consciousness Scale (PSC) and the autism quotient scale (AQ) according to participant group.**

	ASD Group				TD Group				Group Comparisons		
	<i>M</i>	<i>sd</i>	<i>Min</i>	<i>Max</i>	<i>M</i>	<i>sd</i>	<i>Min</i>	<i>Max</i>	<i>t</i>	<i>p</i>	Cohen's <i>d</i>
<b>AQ</b>	35.50	9.03	14	46	14.06	6.72	5	24	6.61	.00	2.69
<b>PSC</b>	23.75	5.35	15	37	21.06	5.81	10	30	1.44	.17	0.48

In the TD Group, there was a significant correlation between scores on the AQ and scores on the PSC,  $r = .58$ ,  $p = .02$ . In the ASD Group, there were no significant correlations between any measures. Difference scores were also calculated by subtracting corrected hit rates in the close other referent condition from corrected hit rates in the self referent condition. This was intended to provide a measure of the self-referencing effect. However, no significant correlations were found between the difference scores and scores on either the PSC,  $r = .11$ ,  $p = .71$ , or the AQ,  $r = .13$ ,  $p = .63$ . All correlations are shown in the tables below.

**Table 2.9 Correlations for the ASD Group.**

	PSC	AQ	Corrected Hit rate (self)	Corrected Hit rate (close other)	Corrected Hit Rate (non-close other)	Corrected Hit rate (Semantic)	Difference Score
PSC	1						
AQ	-.28	1					
Corrected hit rate (self)	-.09	.26	1				
Corrected hit rate (close other)	.07	.07	.79**	1			
Corrected hit rate (non- close other)	.30	.16	.48	.28	1		
Corrected hit rate (semantic)	.05	.13	.71*	.65**	.62**	1	
Difference Score	-.24	.49	.22	-.43	.26	.02	1

\*- Correlation is significant at the .05 level.

\*\* - Correlation is significant at the .01 level.

**Table 2.10 Correlations for the TD Group.**

	PSC	AQ	Corrected Hit rate (self)	Corrected Hit rate (close other)	Corrected Hit Rate (non-close other)	Corrected Hit rate (Semantic)	Difference Score
PSC	1						
AQ	.58*	1					
Corrected hit rate (self)	.08	.22	1				
Corrected hit rate (close other)	-.01	.11	.61*	1			
Corrected hit rate (non- close other)	-.03	.38	.63**	.63**	1		
Corrected hit rate (semantic)	-.43	-.49	.51**	.38	.19	1	
Difference Score	.10	.13	.45	-.43	.001	.15	1

\*- Correlation is significant at the .05 level.

\*\* - Correlation is significant at the .01 level.

### **Discussion: Experiment 2.2**

Experiment 2.2 was intended to be a close replication of Lombardo, Barnes, Wheelwright & Baron-Cohen (2007). As such, we predicted that the SRE would be reduced in participants with ASD and, in particular, that there would be little distinction between recall in the close other and non-close other conditions.



Our results were in line with this. Just as was found in experiment 2.1, recall was higher in the self-referencing condition than in the other referencing conditions amongst the ASD group, suggesting that the SRE is in place in this population. However, recall rates in both the self-referencing and close other referencing conditions were lower among the population with ASD than among the population without, suggesting that the SRE is reduced in strength. Again, this is in line with our earlier results in the psychological domain where it was found that participants with ASD recalled fewer self-referent adjectives than controls and displayed a striking deficit in other referent processing.

As Lombardo et al. (2007) observed, we also found that there was little distinction between the close and non-close other referent conditions in the ASD group, with levels of recall in the non-close other condition being elevated in comparison to controls and levels of recall in the close other condition being reduced. This is in line with numerous studies which have suggested that people with ASD fail to draw distinctions between close and non-close others and, at times, between people, animals and objects (Hirstein, Iversen & Ramachandran, 2001). In other words, we found the same general pattern of results as Lombardo et al. However, a post hoc power analysis revealed that, in order to achieve significance at the recommended 0.8 level (Cohen, 1989), we would have needed a sample size of 88. Therefore, our sample ( $n = 32$ ) was potentially too small to detect between group differences. Importantly, Lombardo et al used a far larger sample size ( $n = 60$ ). This may explain why the effects we found are smaller than those found by Lombardo et al. However, it is important to stress that we did find the same overall pattern of results as Lombardo et al, meaning that it is unlikely that the unusual pattern of results seen in experiment 2.1 were due to a sampling issue.

Critically, Lombardo did not differentiate between physical and psychological trait adjectives. Therefore, it is impossible to directly compare the results of Experiments 2.1 and 2.2 specifically in the physical and psychological domains. These methodological differences may explain why the results of experiment 2.1 in the psychological domain were so different to the results of experiment 2.2 and Lombardo et al. However, the general pattern of results seen in experiment 2.2 is very similar to the general pattern of results seen in experiment 2.1, with other-referent processing being reduced amongst people with ASD.

### **General Discussion**

Together, the two experiments were intended to investigate the nature of the self-referencing bias in a population of adults with ASD. In particular, distinctions between self-referencing in the physical and psychological domains were examined.

Experiment 2.1 successfully indicated that the self-referencing effect is present in both the physical and psychological domains in a population of typically developing adults. These findings are important when considering the conception of the self as an entity with several distinct component parts (Lewis & Brooks-Gunn, 1991). Since the magnitude of the self-referencing effect differs when the physical and psychological elements of the self are considered independently (and there were no significant correlations between physical and psychological difference scores in either the TD or the ASD group), this would indicate that the physical and psychological aspects of the self are dissociable from each other.

Among the group with ASD, the results were less clear-cut. A different pattern of performance to that seen in the TD group was present; more specifically, there appeared

to be a reduced self-referencing effect in the physical domain and an enhanced self-referencing effect in the psychological domain. Again, the differing results in the two domains indicate that they are separate dissociable entities and that, perhaps, they are affected differently by the presence of ASD.

The enhanced effect seen in the psychological domain was driven by a deficit in other-referent processing, rather than an enhancement in self-referent processing. This deficit is one which is to be expected in ASD as people with ASD show impairments of theory of mind (Wimmer & Perner, 1983; Baron-Cohen, Leslie & Frith, 1985), and are consistently unable to interpret or make judgements about the mental and psychological states of others (Frith, 2003). The relatively unimpaired recall of self-referent psychological adjectives is perhaps surprising, given the idea that an impairment exists in the psychological self-concept of those with ASD. However, this result could be a consequence of the rote learning of personality traits associated with the self, which is often seen in people with ASD (Hill, Berthoz & Frith, 2004). Chapter seven attempts to overcome this problem by investigating the relationship between the self-reference effect and the psychological self-concept in ASD using stimuli which would be invulnerable to the effects of prior rote learning (for example, by investigating memory for previously unseen items 'owned' by the self or 'owned' by another).

The key finding here though is that the apparent enhancement of the SRE in the psychological domain is due to a striking lack of other-referent psychological processing. This is predicted by Simulation Theory (Goldman, 1992) which suggests that our understanding of others (i.e. other-referent processing) is dependent upon our understanding of ourselves. This lack of other referent processing is therefore indicative of a potential impairment in self-awareness and in the psychological self-concept, and,

at the very least, is indicative of an impairment of the process employed to create a simulation of the mind of another based on an understanding of the mind of the self. If this lack of other referent processing is indicative of an impairment in the psychological self-concept, then may be that this impairment is in fact greater than the impairment in the physical self-concept since levels of other-referent recall in the physical domain were similar between the two groups.

The results from experiment 2.2 were in line with those of Lombardo et al (2007) and were arguably in line with the results of experiment 2.1. More specifically, both experiments 2.1 and 2.2 demonstrated the presence of an unusual and somewhat reduced pattern of self-referencing in the group with ASD. Despite this, the results of the two experiments are not identical – in particular the results of experiment 2.2 do not show an enhanced SRE of the kind seen in the psychological domain in experiment 2.1. However, since Lombardo et al (2007) did not distinguish between physical and psychological trait adjectives in his original paper, no distinction was made in our replication (and indeed no useful post hoc distinction can be made since equal numbers of physical and psychological words were not used and lists of physical and psychological words were not matched for meaningfulness or likability). This means that it is difficult to draw a direct comparison between the results of experiments 2.1 and 2.2. A smaller number of psychological adjectives were used in experiment 2.2 which may explain why the pattern of results seen here is more in line with the reduced SRE seen in the physical domain in experiment 2.1.

Another important distinction between the two experiments is that, the ‘other’ conditions employed were not equivalent; in experiment 2.2, the non-close other condition involved a fictional character, while the close other condition involved the

participant's best friend. There are several flaws in this design; it has been suggested (Mackintosh & Mathews, 2003) that the self-schema may be expanded to partly include close others, meaning that the best friend condition may not be a true test of other referent processing since the other in question is perhaps not distinct enough from the self. The Harry Potter condition can also be seen as having flaws; Harry Potter is not real and therefore information, particularly psychological information, relating to 'him' may not be processed in the same way as psychological information relating to a real celebrity such as Cheryl Cole. The other referencing condition employed in experiment 2.1 used a celebrity (i.e. a real person, but not a real person with whom the participant was personally acquainted). Therefore, in cognitive processing terms, this other condition may have come part way between the non-close other and close other referencing conditions used in experiment 2.2. This may explain why the near-absence of other-referent processing in the non-close other referencing condition in experiment 2.1 did not occur in the other referent condition in experiment 2.2.

Having said this, what is evident is that the same general pattern of results was displayed in both studies as, in both studies, self-referencing was reduced in ASD. This effect was apparent in experiment 2.2 and in the physical domain in experiment 2.1. This reduction was also present and arguably greater in the psychological domain in experiment 2.1 as there was a striking absence of other-referent processing. This suggests that the results here are in line with our initial hypothesis – the SRE is impaired to a greater degree in the psychological domain, suggesting a greater impairment in the psychological self-concept than in the physical self-concept.

The experiment presented in the next chapter examines the self-reference effect in primary school age children with a diagnosis of ASD. It was hoped that, by working

with children, we would overcome the problem of rote learning of psychological traits, since children are unlikely to have learnt their own traits to the same extent as adults. If, the self-referencing effect observed in experiment 2.1 in the psychological domain in the ASD group was a consequence of rote learning of personality traits, then we would expect that, among primary school age children, the self-referencing effect would be absent or reduced.

## **Chapter Three: The Emerging Physical and Psychological Self: Childhood Self-Referencing in Autism Spectrum Disorders**

Previous chapters have outlined the existing evidence for an impairment of the psychological self-concept in adults with ASD, while the physical self-concept remains largely intact. There is also evidence that this impairment exists in childhood. For example, children with ASD fail to show the expected memory advantage for events which they have personally experienced as opposed to events experienced by others (Millward, Powell, Messer & Jordan, 2000). Of particular relevance to self-concept impairments is the fact that people with ASD fail to show the so-called reminiscence bump (Crane & Goddard, 2008). The reminiscence bump describes the phenomenon by which TD individuals remember more details of events from adolescence and early adulthood than from other periods of life. This is the period which is key to the development of an identity separate from that of one's parents and peer group (and therefore to the development of the self-concept) (Erikson, 1980). Adults with ASD tend to recall equal amounts of details from all periods of life, suggesting less of a self-focus during the years of the reminiscence bump. This may in turn hint at abnormal or impaired development of the self-concept during childhood.

Before exploring the development of the self-concept in ASD in more detail, it is worth recapping its development in children without ASD and, more specifically, how this differs from the development of the self-concept in children with ASD. TD children begin to show signs of a developing self-concept at around the age of 18 months. At this age, they are able to recognise their own reflections in mirrors and will respond with surprise to unexpected changes in their appearance (Amsterdam, 1972). The self is viewed in almost purely physical terms in early childhood; when children in this age

group are asked to locate the self, they will often point to a part of the body (usually the head) (Broughton, 1978). At around the age of six or seven, as children enter middle childhood, the self starts to be viewed as something more abstract and intangible.

This shift from a purely physical self-concept to a self-concept which incorporates more psychological aspects has been widely documented. Damon (1991) administered the self-understanding interview to TD children, ranging in age from early childhood to adolescence, and proposed that the self-concept develops in four stages, two of which are physical and two of which are psychological. The very youngest children describe themselves almost exclusively in terms of physical appearance, while children at the next physical stage display the 'active self' which involves an understanding of the self as an agent of action. At around the age of six or seven years old, children begin to describe themselves with reference to personality and, by adolescence, the self is commonly defined in terms of moral, religious and political beliefs or in terms of membership of certain social groups. At all ages, all four facets of the self-concept are present, but each one dominates at a different age.

There is some evidence to suggest that children with ASD may not make the shift from a purely physical notion of self to a partly psychological notion of self, or at least, may not make this shift in its entirety. This would mean that, in ASD, the physical self-concept is unimpaired, while the psychological self-concept is not fully formed.

Evidence for this theory largely focuses on the physical self-concept. Children with ASD usually do not display mirror recognition at the expected chronological age of 18 months. However, when mental rather than chronological age is taken into account, they do display mirror recognition at around the same time as their TD peers (Ferrari & Matthews, 1983). Children with ASD are also able to recognise delayed video images of



themselves (Lind & Bowler, 2009) and discriminate between self and other caused changes in their environment (Williams & Happe, 2009).

The body of research investigating the psychological self-concept in ASD is somewhat more limited, perhaps due to methodological difficulties with assessing the self-concept in pre-verbal children. However, various features of ASD could be traced back to an underlying deficit in the psychological self-concept. For example, the unusual pronoun use often seen in ASD may be symptomatic of difficulties distinguishing between the self and the other (Lee, Hobson & Chiat, 1994). Children and adults with ASD also often report high levels of alexithymia (an inability to describe one's own emotions) (Shalom, Mostofsky, Hazlett, Goldberg, Landa, Faran, et al, 2006). Adults with ASD are also more likely to report physical details of inner experience than more mental ones (Hurlbert, Happe & Frith, 1994).

Very little experimental work has examined the distinction between the physical and psychological self-concept in children with ASD. Lee and Hobson (1998) administered Damon and Hart's (1986) self-understanding interview to children and adolescents with ASD. Although, the children with ASD generated a similar number of self-descriptive statements to the children without ASD, a greater proportion of these were physical in nature. In particular, children with ASD made very few social statements and none made any reference to friends or to being a member of a social group. Other kinds of psychological statements were generated, but they were generic in nature and had something of a rote learned quality. Farley, Lopez and Saunders (2010) replicated this study and found similar results. Their participants also showed little understanding of the ways in which personality can change over time and, instead, viewed personality as a stable construct.

The current study seeks to further explore the nature of the physical and psychological self-concepts in primary school age children with a current diagnosis of ASD. The paradigm used here examines the self-concept in the domain of memory by utilizing the self-referencing effect. This study directly follows on from the study with adults presented in Chapter 2 and was conducted in response to the slightly unusual results generated in the adult study. Amongst the adults with ASD, self-referencing was reduced in the physical domain and enhanced in the psychological domain. We had initially predicted that the self-reference effect would be intact in the physical domain and absent in the psychological domain given the wealth of evidence which suggests that the physical self-concept is intact in ASD and the psychological self-concept is impaired. However, our results suggest that there may be a slight impairment of the self-concept in the physical domain. The enhanced self-referencing effect in the psychological domain appears to be driven by a lack of other-referent processing, rather than an enhancement of self-referent processing. This would be in line with the idea of an impairment in the psychological self-concept. What is more unusual is that, although, memory for self-referent psychological adjectives was reduced in the group with ASD, this reduction was smaller than expected. We suggested that this may be because adults with ASD may learn their own personality traits by rote, thus allowing them to perform very well on this kind of test of self-referential memory. It is hoped that, by repeating this task with young children who are less likely to have learnt their own personality traits by rote, we may be able to gain a set of results which are more representative of the state of the psychological self-concept in ASD.

In the current study, participants were presented with words related to either the self or to a non-close other (Harry Potter). Importantly, the words were divided up into adjectives which described either physical appearance or words which described

personality. Experiment 3.1 was administered to TD children only; as very few self-referencing studies have been conducted in young children, it was felt that experiment 3.1 was necessary to establish the presence of the expected self-referencing effect within a TD sample. Experiment 3.2 was administered to children with a current diagnosis of ASD, as well as a sample of age and IQ matched TD children. It was predicted that the TD children would display a self-referencing effect in both the physical and psychological domains, while the children with ASD would display a self-referencing effect in the physical domain only.

### **Method: Experiment 3.1**

#### **General**

All participants completed a memory task (described below) which took approximately half an hour.

#### **Participants**

Prior written informed consent was given by a parent or guardian of all participants in accordance with the University of Durham Research Ethics Committee. In addition to this, participants themselves gave verbal consent at the start of the testing session.

Participants consisted of 21 children between the ages of 8 and 10 (8 male). This age range was selected as children in this age group were likely to have a fairly mature physical self-concept and a developing psychological self-concept. It was decided to use only children aged eight or over as previous research has suggested that children below this age may show little evidence of a psychological self-concept (Damon & Hart, 1986). The relatively narrow age range meant that all the children were at the same stage of self-concept development according to Damon and Hart's four stage self-concept model; they had moved beyond stage two, the final purely physical stage, and were partway through stage three, the first of the psychological stages. We therefore predicted that age would have no impact on task performance. By using children as

young as eight, it was also hoped that we would pick up on any developmental delay in manifesting the psychological self-concept shown by the group with ASD who took part in experiment 3.2. All participants had no current or past diagnoses of developmental disorders, and all participants had a full scale IQ score within the normal or high range (as assessed by the Wechsler Abbreviated Scales of Intelligence). ‘Normal’ is defined here as being an IQ score between 85 – 115 (i.e. within one standard deviation of the population average of 100). Participant characteristics are shown in the table below.

**Table 3.1: Participant Characteristics**

	<b>Minimum</b>	<b>Maximum</b>	<b><i>M</i></b>	<b><i>sd</i></b>
<b>Age</b>	8.0	10.0	9.19	0.87
<b>Verbal IQ</b>	84	145	114.95	19.43
<b>Performance IQ</b>	78	125	100.48	11.84
<b>Full Scale IQ</b>	84	138	107.76	15.94

## **Materials and Procedure**

### **Selection of stimuli and task design.**

60 trait adjectives (see Appendix 2), half of which could be used to describe personality/psychological characteristics, and half of which could be used to describe physical characteristics, were selected for use in the study. The personality trait adjectives and physical trait adjectives were selected on the basis of mean age of acquisition. Each word included had a mean age of acquisition of no older than six years. This was to ensure that the youngest children in the study were able to understand fully all the words used. As far as possible, care was taken to ensure that similar numbers of words judged by the experimenter to have positive and negative valences

were included in each list so that differing responses to the various lists could not be attributed to the likability of the words in question.

Three counterbalanced versions of the task were created. Each version comprised three sub-lists of 20 adjectives each, namely 20 adjectives to be used in the self-referencing condition, 20 to be used in the other referencing condition and 20 to be used as lures. Half of all the words used in each sub-list were judged to be physical trait adjectives and half were judged to be psychological trait adjectives.

The sub-lists were rotated through three counterbalanced versions of the task, such that each sub-list appeared as self-referential target items in one version, other-referential target items in one version, and lure items in one version.

### **Encoding phase.**

During the encoding phase, 40 trait adjectives were presented, half in the self-referencing condition and half in the other referencing condition. In the self-referent condition, participants assessed whether or not the adjective was representative of them. In the other referent condition, participants judged whether or not the adjective was representative of the fictional character, Harry Potter. Prior to test, participants' familiarity with Harry Potter was assessed by asking how many Harry Potter books they had read or films they had seen. Three participants at the lower end of the age spectrum had only a very limited knowledge of the Harry Potter franchise and so, for these participants, an alternative fictional character with whom the participant was familiar, such as Milly Molly Mandy, was used instead.

Each adjective was presented, following a question designed to elicit either self-referential or other-referential processing, for example '*Brave*' '*Does this word describe Harry Potter?*' The structure of the questions was identical between the self- and other-referent conditions. Participants were instructed to respond verbally to each question by saying either 'yes' or 'no'. Their answers were then recorded.

Adjectives were presented in a pseudo-random order, subject to the constraint that no more than four physical or four psychological trait adjectives appeared consecutively, and no more than four self- or other-referential questions were presented consecutively.

### **Test phase.**

A standard surprise recognition test procedure was used. The 40 previously seen adjectives were presented along with a set of lures; a previously unseen set of 10 physical and 10 psychological trait words. Adjectives were presented individually in a pseudo-random order, subject to the constraints detailed above. Participants were asked to state whether or not each word had appeared in the previous task.

### **Scoring.**

The raw data was used to calculate hit rates for each of the four word types (physical self-referent, physical other-referent, psychological self-referent and psychological other-referent). These hit rates comprised the proportion of words in each of the four categories which were correctly remembered by participants. A false alarm rate was also calculated which was the proportion of physical and psychological lure words incorrectly identified by participants as having been present in the encoding condition. Corrected hit rates were then calculated which took false alarm rates into account. These

were calculated by subtracting the false alarm rates for physical and psychological words from the hit rates for physical and psychological words.

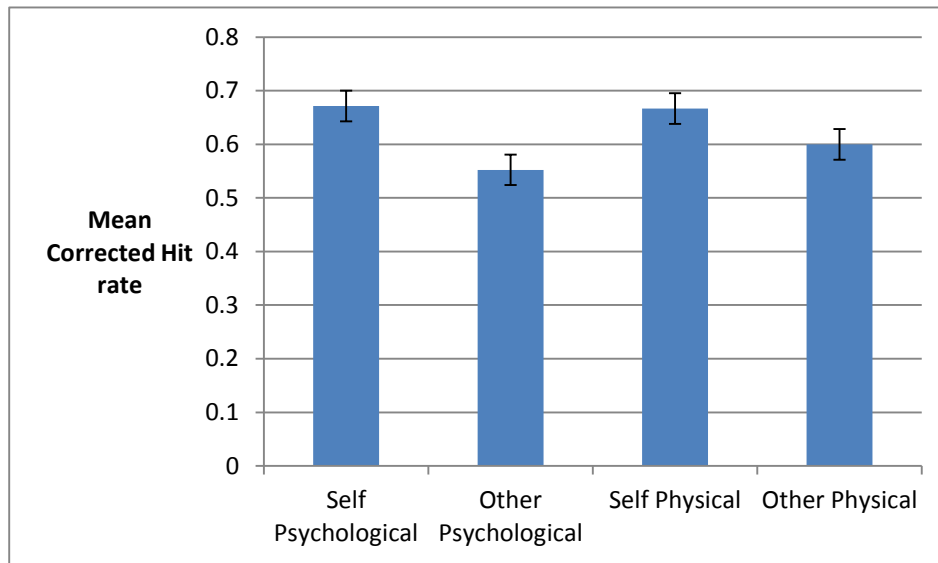
### **Results: Experiment 3.1**

The raw data were used to calculate hit rates, false alarm rates and corrected hit rates for physical and psychological self and other referent words. Means and standard deviations for these are shown in the table below. Corrected hit rates are shown in figure 3.1.

**Table 3.2: Hit rates, corrected hit rates and false alarm rates for self and other referent stimuli.**

<b>Measure</b>	<b>Referent</b>	<b>Word Type</b>	<b><i>M</i></b>	<b><i>sd</i></b>
<b>Hit rates</b>	<b>Self</b>	<b>Psychological</b>	.85	.12
		<b>Physical</b>	.88	.14
	<b>Other</b>	<b>Psychological</b>	.73	.17
		<b>Physical</b>	.81	.13
<b>Corrected Hit Rates</b>	<b>Self</b>	<b>Psychological</b>	.67	.22
		<b>Physical</b>	.67	.20
	<b>Other</b>	<b>Psychological</b>	.55	.29
		<b>Physical</b>	.60	.19
<b>False Alarm Rates</b>		<b>Psychological</b>	.18	.16
		<b>Physical</b>	.21	.13

Figure 3.1. Mean corrected hit rates. Error bars represent 1 SEM.



#### Analysis of corrected hit rates.

Corrected hit rates were then calculated by subtracting physical and psychological false alarm rates from physical and psychological hit rates respectively. This gave a measure of the self-referencing effect which took false alarm rate into account.

A repeated measures ANOVA was then conducted on these data with within subjects factors of Referent and Adjective Type and between subjects factors of Age and Gender. A significant main effect of Referent was found,  $F(1,15) = 7.66, p = .01, \eta^2 = .34$ , Cohen's  $d = 1.41$ . Paired sample t-tests revealed significant differences in hit rates in both the physical,  $t(20) = 3.48, p = .002$ , Cohen's  $d = .34$ , and the psychological,  $t(20) = 2.75, p = .01$ , Cohen's  $d = .46$  domain. This reflects the fact that corrected hit rates for self referent words were higher than corrected hit rates for other referent words in both the physical and the psychological domains.

The main effect of Adjective Type was non-significant,  $F(1,15) = .02, p = .90, \eta^2 = .01$ . The main effects of Age,  $F(1,15) = .18, p = .83, \eta^2 = .02$ , and Gender,  $F(1,15) =$



.08,  $p = .78$ ,  $\eta^2 = .05$ , were also non-significant. Similarly, the interaction effects of Referent and Adjective type,  $F(1,15) = .63$ ,  $p = .44$ ,  $\eta^2 = .04$ , Referent and Age,  $F(1,15) = .27$ ,  $p = .77$ ,  $\eta^2 = .04$ , Referent and Gender,  $F(1,15) = .34$ ,  $p = .57$ ,  $\eta^2 = .02$ , Word Type and Age,  $F(1,15) = .06$ ,  $p = .94$ ,  $\eta^2 = .01$ , and Word Type and Gender,  $F(1,15) = .44$ ,  $p = .52$ ,  $\eta^2 = .03$ , were non-significant. None of the three or four way interactions were significant.

### **Categorical analysis of data.**

A categorical analysis was carried out to examine whether or not each individual participant demonstrated the self-referencing effect in each domain. This was conducted by subtracting the number of other referent words recalled from the number of self referent words recalled for each participant. Participants were deemed to have shown a self referencing effect if the number generated was greater than 0. In the physical domain, five of the 21 children did not show the expected self referencing effect (in one case, this was due to a ceiling effect as the child simply remembered 100% of the words in both referencing conditions). In the psychological domain, 4 children did not show the expected self referencing effect (the same child who showed a ceiling effect in the physical domain also showed a ceiling effect here. Of the other three children, one failed to show a self-referencing effect in either domain, but performance was below ceiling). Age had no effect on whether or not children displayed the self referencing effect. Table 3.3 shows how many more (or less) words were recalled in the self referent condition compared to the other referent condition.

**Table 3.3. Breakdown of Categorical Analysis.**

	Word Type	Number of words recalled in the self-referent condition compared to the other-referent condition.						
		-3	-2	-1	0	+1	+2	+3 or more
No. of Participants	Physical	0	0	3	1	8	5	1
	Psychological	0	1	1	2	8	6	2

**Discussion: Experiment 3.1**

The results were in line with our initial predictions. Participants displayed the self-referencing effect in both the physical and the psychological domain. This is in line with the results of numerous studies with adults in which a persistent memory advantage has been observed for self-referent stimuli over other-referent stimuli (Symons & Johnson, 1997, Yiend, Mackintosh & Mathews, 2005).

The observation of this effect in children as young as eight suggests that the self-referencing effect is a cognitive bias which is in place from an early point in development. It is difficult to test its presence in younger children, due to the complexity of stimuli needed, but, there is some evidence from studies of ownership that even pre-school children may have an enhanced memory for objects linked to the self as opposed to objects linked to another person (Cunningham, Turk, MacDonald, & MacRae 2008).

The findings here are in line with the existing literature on the development of the self-concept in young children, in that they show the self-referencing effect in both the physical and psychological domains. The results of Damon and Hart's self-understanding interview (1986) would suggest that, by the age of eight, typically developing children will have an almost fully-developed physical self-concept and a largely developed psychological self-concept. In particular, children of this age tend to

describe themselves with reference to the thoughts, feelings and abilities of others. This is of particular relevance to the current study where, during the encoding phase, children were asked to make judgements about their own personalities interspersed with judgements about the personality of another.

It would be interesting to carry out this study (or a simplified version of it) with five and six year-olds. The expectation would perhaps be that these younger children would show the self-referencing effect in the physical domain only, since the psychological self-concept at this age is relatively underdeveloped. More importantly, among individuals with ASD, the expectation would be that children with this disorder would show the self-referencing effect in the physical domain only, since the psychological self-concept is relatively underdeveloped in ASD.

### **Method: Experiment 3.2**

#### **General**

The procedure used in experiment 3.2 was identical to the one used in experiment 3.1. In order to verify the diagnosis of the children with ASD and screen for the presence of ASD-like features in the TD group, the social responsiveness scale (Constantino, 2005) was completed by a parent or guardian. This questionnaire provides a measure of participants' communication and social interaction abilities.

#### **Participants**

24 children between the ages of 7 and 10 took part in experiment 3.2. 12 of these (11 boys, 1 girl) had a current diagnosis of Asperger's Syndrome or Autism Spectrum Disorder. The children in the group with ASD were intellectually high functioning and, with two exceptions, attended mainstream primary schools. All diagnostic information was checked thoroughly and 11 of the 12 children scored above the cut-off for autism

spectrum disorder on the social responsiveness scale (SRS-2) (Constantino, 2005). The remaining child scored below the cut-off for ASD on the SRS-2. However, he had a current diagnosis of autism spectrum disorder and attended a specialist school for children with ASD.

The remaining 12 children (8 boys, 4 girls) had no current or past history of developmental disorders and all scored below the cut-off for autism spectrum disorder on the SRS-2. These typically developing (TD) children were matched with the ASD group for age and IQ. Participant characteristics and comparisons between groups are outlined in the table below. Verbal IQ (VIQ), Performance IQ (PIQ) and Full Scale IQ (FSIQ) were measured using the Wechsler Abbreviated Scales of Intelligence (WASI). Group differences in age and IQ were non-significant.

**Table 3.4: Participant Characteristics and Group Contrasts.**

	ASD Group		TD Group		Group Comparisons		
	M	<i>sd</i>	M	<i>sd</i>	<i>t</i>	<i>p</i>	Cohen's <i>d</i>
<b>Age</b>	8.92	0.79	9.0	0.60	0.27	.80	-0.13
<b>VIQ</b>	111.08	14.99	112.58	14.88	0.21	.84	0.10
<b>PIQ</b>	107.17	17.46	103.00	15.85	0.55	.59	0.25
<b>FSIQ</b>	110.33	15.40	108.83	15.59	0.22	.83	0.10
<b>SRS</b>	78.25	9.94	46.75	5.85	10.29	.00	3.86

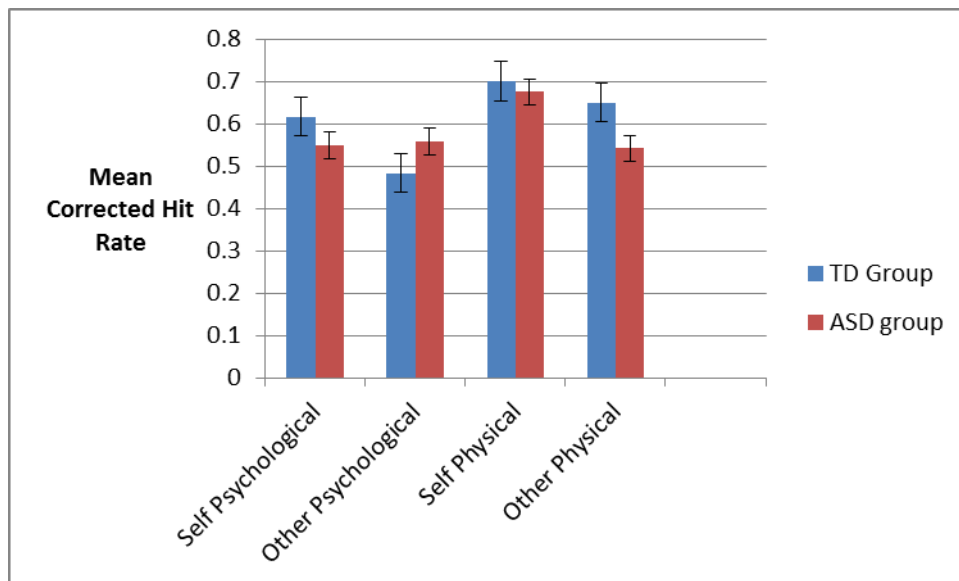
### **Results: Experiment 3.2**

The raw data were used to calculate hit rates, false alarm rates and corrected hit rates (hit rates minus false alarm rates) for the TD and ASD groups. Mean hit rates, false alarm rates and corrected hit rates are shown in the table below. Corrected hit rates are shown in figure 3.2.

**Table 3.5: Hit rates, corrected hit rates and false alarm rates for self and other referent stimuli**

			ASD		TD	
			<i>M</i>	<i>s.d.</i>	<i>M</i>	<i>s.d.</i>
<b>Hit Rates</b>	<b>Self-Referent</b>	<b>Psychological</b>	.81	.17	.86	.12
		<b>Physical</b>	.85	.16	.87	.20
	<b>Other-Referent</b>	<b>Psychological</b>	.82	.21	.73	.09
		<b>Physical</b>	.72	.19	.82	.12
<b>False Alarm Rates</b>	<b>Psychological</b>		.26	.10	.24	.12
	<b>Physical</b>		.18	.15	.17	.18
<b>Corrected Hit Rates</b>	<b>Self-Referent</b>	<b>Psychological</b>	.55	.19	.62	.21
		<b>Physical</b>	.68	.22	.70	.25
	<b>Other Referent</b>	<b>Psychological</b>	.56	.21	.48	.12
		<b>Physical</b>	.54	.23	.65	.22

*Figure 3.2. Corrected hit rates for ASD and TD groups. Error bars represent 1 SEM.*



A repeated measures ANOVA with within subjects factors of Adjective Type (physical and psychological) and Referent (self and other) and between subjects factors of Group (ASD and TD) and Gender was first conducted on the corrected hit rate data. There was a significant main effect of Referent,  $F(1,20) = 10.99, p = .003, \eta^2 = .36$ , Cohen's  $d = 0.29$ . T tests produced a significant difference between corrected hit rates for self and other referent words in the physical domain,  $t(23) = 3.41, p = .002$ , Cohen's  $d = 0.17$ , and a near significant difference in the psychological domain,  $t(23) = 1.93, p = .07$ , Cohen's  $d = 0.38$ . This reflects the fact that, in both domains, the mean corrected hit rate for self referent words, ( $M$  (psychological) = .54,  $SD = .22$ ;  $M$  (physical) = .69,  $SD = .23$ ) was higher than the mean corrected hit rate for other referent words ( $M$ (psychological) = .48,  $SD = .20$ ;  $M$  (physical) = .60,  $SD = .23$ ).

The main effect of Adjective Type was also significant,  $F(1,20) = 5.74, p = .03, \eta^2 = .22$ , Cohen's  $d = .58$ . There was a significant difference between corrected hit rates for self referent physical words and self-referent psychological words,  $t(23) = 2.37, p = .03$ , Cohen's  $d = .21$ . This reflects the fact that the mean corrected hit rate for self referent physical words (.69,  $SD = .23$ ) was higher than the mean corrected hit rate for self referent psychological words (.59,  $SD = .20$ ). There was no significant difference between corrected hit rates for other referent physical and other referent psychological words,  $t(23) = 1.54, p = .14$ , Cohen's  $d = .18$ .

The main effect of Gender was non-significant,  $F(1,20) = 2.46, p = .13, \eta^2 = 0.11$ . The main effect of group was also non-significant,  $F(1,20) = 1.96, p = .18, \eta^2 = .09$ . This suggests that there were no differences in general memory performance between the two groups. This result is in line with those seen in experiments 2.1 and 2.2. All two, three and four way interaction effects were non-significant.

Categorical analysis of the data was also carried out to determine how many of the children demonstrated the self-referencing effect and to further explore any differences in results between the ASD group and the TD group. In the TD group, 7 out of the 12 children showed the self-referencing effect in the physical domain. In the ASD group, 10 of the 12 children showed some self-referencing effect in the physical domain. A chi square test revealed that the difference between the TD and ASD groups was non-significant,  $X^2(1, N = 12) = 1.82, p = .18, \Phi = .18$ .

In the psychological domain, 10 of the children in the TD group showed the self referencing effect. In the ASD group, only 2 of the 12 children showed evidence of the self-referencing effect in the psychological domain (none of these children performed at ceiling). A chi square test revealed that, in the psychological domain, the difference between the TD and ASD groups was significant,  $X^2(1, N = 12) = 10.67, p < .01, \Phi = .67$ . In other words, the self-referencing effect was present in the physical domain in the ASD group, but largely absent in the psychological domain. Table 3.5 shows a breakdown of the categorical analysis.

**Table 3.6. Breakdown of Categorical Analysis**

		Number of words recalled in the self-referent condition compared to the other-referent condition						
		-3	-2	-1	0	+1	+2	+3 or more
No of participants	Physical (ASD group)	0	1	0	1	4	4	2
	Psychological (ASd group)	0	1	3	6	0	2	0
	Physical (TD group)	0	1	1	3	5	2	0
	Psychological (Td group)	0	1	1	0	5	2	3

### **Discussion: Experiment 3.2**

The results from the TD group were in line with those of experiment 3.1. Participants showed a self-referencing effect in both the physical and the psychological domains. Categorical analysis demonstrated that this self-referencing effect was present in 10 out of the 12 participants in the psychological domain and 7 out of the 12 participants in the physical domain. This is in line with existing literature on self-referencing and the development of the self-concept (Tversky & Kahneman, 1974; Damon & Hart 1986).

The results of the ASD group are similar to those of one of our adult studies (experiment 2.2). An examination of group means demonstrated that children in the group with ASD remembered fewer self and other referent words in the physical domain than children in the TD group. This is in keeping with earlier work which suggests that the self-referencing effect is often reduced in ASD. For example Lombardo, Barnes, Wheelwright and Baron-Cohen (2007) found a reduced self-referencing effect amongst a population with ASD who were asked to make judgements about themselves, a close friend, and a fictional character. This would imply, contrary to our predictions, that the physical self-concept in ASD is not fully intact. A counter-argument to this, is that people with ASD have an intact physical self-concept, but are simply interested in the physical features of others and the self to an almost-equal degree; whether or not this is the case cannot really be ascertained from the data at hand. However, this idea is plausible in the context of what we know of ASD; the physical features of another person are perhaps easier to process than the psychological features of another, meaning that people with ASD may devote more of their cognitive resources to processing physical features rather than devoting equal amounts to the processing of physical and psychological features. This would lead to some flattening of



the self-referencing effect in the physical domain as more attention would be paid to physical features than is usual.

If the physical self-concept in ASD is not intact, it could be argued that the psychological self-concept in ASD is even less intact. Accordingly, most of the ASD group showed no evidence of a psychological self-referencing effect here (only two children remembered more self-referent than other referent psychological words and figures that low are likely due to chance). Hit rates and corrected hit rates for self-referent psychological words were also lower for the ASD group than for the TD group. This was not the case for self-referent physical words. This would itself be evidence for an impaired psychological self-concept in ASD.

In our earlier adult study (experiment 2.2), we found an enhanced self-referencing effect in the psychological domain. At first glance, this seems to be at odds with the results here. However, it was argued that the self-reference effect which was present in the adult study is driven, not by enhanced recollection of self-referent stimuli, but by a paucity of recall of other referent stimuli. Again, this is evidence for the idea of an impaired psychological self-concept in ASD since the thoughts feelings and personalities of others are used as a model for understanding the thoughts, feelings and personalities of the self (Goldman, 2006). Given the disparity of ages between the participants in the two studies, it could be argued that the psychological self-concept, and with it the psychological self-referencing effect, emerges at a later point in developmental time in children with ASD than in TD children. And, given the performance of the adults, when the psychological self-concept does begin to emerge, it may be impaired to a greater degree than the physical self-concept.

Another possible explanation for the difference in results between the children and the adults could be to do with the suggestion that people with ASD sometimes learn their own personality traits by rote (Hill, Berthoz & Frith, 2007). This could lead to enhancement of recall of words in the self-referent condition as rote learning may cause certain personality descriptors to be easily accessible in memory. In children, this effect may not be present as children may not display the rote learning of personality traits to the same degree as adults.

The pattern of results shown by the ASD group seems to indicate an interest in all things physical, with the flattening of the self-reference effect in the physical domain caused perhaps, not by a lack of interest in others, but by an interest in their physical, rather than their psychological, features. From this data, it is difficult to surmise whether or not the physical self-concept is impaired. We can, however, surmise that the psychological self-concept is impaired in children with ASD in this age group.

### **General Discussion**

Experiments 3.1 and 3.2 were intended to investigate the physical and psychological self-concepts in children of primary school age, both with and without autism.

Experiment 3.1 involved typically developing children only. The purpose of this experiment was twofold; firstly, to provide a large baseline for the sample of children with ASD in experiment 3.2, and, secondly, to aid in furthering our understanding of the way in which the self-concept typically develops in childhood.

The results for experiment 3.1 were as predicted; the children displayed a significant self-referencing effect in both the physical and the psychological domain. Self-referencing is a well-documented phenomenon in adult populations, but has been less extensively studied in children. Hammen, & Zupan, (1984) found a self-reference effect

in children, but with a paradigm which did not involve an other referent condition.

These results are therefore important in demonstrating that the self-reference bias seen so often in adults is present from at least middle childhood onwards.

Returning to notions of the self, these results suggest that both the physical and the psychological self-concept are therefore fairly highly developed by the age of eight. This is what would be expected based on previous research; Guardo and Bohan (1971) demonstrated that children over the age of 7 no longer viewed the self as part of the body, suggesting a cognitive move away from a purely physical concept of self, and Damon and Hart (1986) also identified 7 as the age at which children move away from physical ideas of self and begin to appreciate the self as a mental and social concept as well. In light of these ideas, it is unsurprising perhaps that the self-referencing effect was observed in both the physical and the psychological domains.

Also of note is the fact that the self-referencing effect in experiment 3 was slightly (although not significantly) stronger in the physical domain than in the psychological domain. A ramification of this particular finding is that it lends support to the idea that the self-concept is formed of several cognitively distinct component parts. These parts are able to develop relatively independently of one another and, as distinct, but related cognitive entities, are able to generate cognitive biases of varying strength.

The TD group who took part in experiment 3.2 displayed the same pattern of results as the group in experiment 3.1. Among the ASD group, however, the results were somewhat different. The ASD group displayed the self-referencing effect in the physical domain only. This effect was somewhat reduced, while the self-referencing effect in the psychological domain was notable for its absence. This is the pattern of results we would expect from a population with an impairment of the psychological self-concept.

The absence of the self-referencing effect in the psychological domain seems to have been driven by a low frequency of recall for both self and other referent psychological words. This is as expected; it has been extensively documented that people with ASD are unable to understand theory of mind (Baron-Cohen, Leslie & Frith, 1985; Wimmer & Perner, 1983) or make judgements about the mental states, beliefs and intentions of others (Frith, 2003). People with ASD also commonly display alexithymia (Shalom, et al 2006) which implies a lack of understanding of their own mental states and traits. The results of this study, when taken with the finding amongst adults that the psychological self-reference effect is present in ASD, but is driven by a paucity of other-referent processing, begin to paint a picture of a psychological self-concept which emerges relatively late in development and does not develop fully.

The flattening of the self-reference effect seen in the physical domain suggests that an impairment of the self-concept is also present here, although it is perhaps less severe than that which is found in the psychological domain. The pattern of results here is similar to the pattern of adult results described earlier. This finding is also in line with the findings of Lombardo, Barnes, Wheelwright and Baron-Cohen (2007) and Henderson and Zahka (2009) who also found reduced self-referencing effects in ASD. This finding may be indicative of the fact that the physical self-concept is not fully intact in ASD, although the fact that some degree of self referencing is still present would suggest that elements of the physical self-concept remain unimpaired. The following chapter attempts to explore the degree of impairment to the physical self-concept which is present in children with ASD.

In conclusion, the results of this study suggest that both the physical self-concept and the psychological self-concept are impaired to some degree in children with ASD, the psychological self-concept perhaps more markedly so.

## **Chapter Four: The Rubber Hand Illusion: Exploring the Physical Self-Concept in Autism Spectrum Disorder**

Given the results presented in the previous three chapters, we have suggested that the physical self-concept is predominantly undiminished in autism spectrum disorders (ASD), although some degree of impairment or developmental delay may be present. This chapter explores that idea by examining body ownership in children with ASD. Body ownership is the idea that the body belongs to you and is constantly present. It also incorporates ideas of the body's physical location in space (James, 1890; Gallagher, 2000). Body ownership is an integral part of the physical self-concept and disruptions of the sense of body ownership can be causal factors in a number of psychological disorders including schizophrenia and anorexia. As body ownership only is predominantly physical, we would expect it, at first glance, to be relatively unimpaired in ASD.

Cognitive processing which relates to body ownership is reliant upon the convergence of information from several different sensory modalities including touch, sight and proprioception (the sense of where the body is in space). For example, when a part of the body is touched, the agent will look towards the touch to help locate it in space (Driver & Spence, 1998; Groh & Sparks, 1996). Studies of patients with various neurological disorders, such as autopagnosia, which render them unable to identify parts of the body, have reinforced this idea. In autopagnosia, for example, the lesion is to the parietal lobes, the area in which sensory integration occurs, rather than in a primary sensory area such as V1 (Ehrsson et al, 2004, 2005).

Body ownership is usually investigated by studying cases of multisensory conflict (i.e. situations where information from one sensory modality is altered so that it no longer correlates with information from other sensory modalities). One example of this is the ‘ventriloquist effect’ where the auditory location of a sound differs from the spatial location of the speaker (Bonath et al, 2007). Another commonly used paradigm involves visual capture. This occurs when misleading visual information causes people to mistake the location of one of their own limbs in space. For example, participants can be tricked into thinking that a plastic finger protruding from underneath a cloth is their real finger when their real finger is, in fact, still occluded by the cloth (Tastevin, 1937). Visual capture also occurs when visual perception is distorted through the use of prisms (Mon-Williams, Wann, Jenkinson & Rushton, 1997). Perhaps the most commonly used experiment which tests visual capture is the rubber hand illusion (RHI).

The RHI is defined as being the temporary incorporation of the rubber hand into the participant’s internal body representation (Kammers, deVignemont, Verhagen & Dijkermann, 2009). During the RHI, the participant’s real hand is concealed, while a rubber hand is placed in sight instead. Participants are instructed to concentrate on the rubber hand during synchronous stroking of the rubber hand and the real hand.

Eventually, this leads to confusion between the rubber hand and the real hand.

Typically, after several minutes of synchronous stroking, participants will display proprioceptive drift in the direction of the rubber hand (i.e. they will perceive their real hand as being closer in space to the rubber hand than it actually is). In some cases, participants will also start to ‘feel’ the stroking of the rubber hand (Botvinick & Cohen, 1998). Other studies have found that the RHI occurs to some degree after only very short periods of synchronous stroking (Pavani, Spence & Driver, 2000).

The rubber hand illusion represents a three-way interaction between vision, touch, and proprioception. It leads to a visual adaptation of proprioception, which is similar to the visual adaptation that occurs after people have been viewing the visual world through a prism. The rubber hand adaptation results therefore, not just from visual information, but from the interaction between visual and tactile information (Welch, Widawski, Harrington & Warren, 1979).

Tsakiris and Haggard (2005) suggest that the RHI is dependent upon two separate cognitive processes, namely a bottom-up process by which visual and tactile information is integrated, and a process by which phenomenological changes in body representation occur, thus allowing the rubber hand to be perceived as part of the body. This means that the RHI involves an interaction between localised visuotactile integration and more general body schemas.

There is a large body of research investigating the RHI in typically developing participants, but there is a relative paucity of information regarding the RHI in participants with ASD. The evidence that we do have suggests that participants with ASD are vulnerable to the RHI, but they are somewhat less vulnerable than participants without ASD. Cascio, Foss-Feig, Burnette, Heacock and Cosby (2012) found that children with ASD did experience the RHI (feelings of ownership over the rubber hand), but only after six minutes of synchronous stroking, whereas typically developing children experienced the RHI after only three minutes of synchronous stroking. However, the groups of children with and without ASD were not fully matched in this study and a very wide age-range (8 to 17 years) was tested (although, to our knowledge, the effects of age on the RHI have never been investigated, it is likely that, with an age range as broad as this, age may have had an effect on performance. This likelihood is



increased by the fact that children in the ASD group may have had a mental age which was below their chronological age). Results from an adult study are similar; adults with ASD did experience the illusion, but they displayed less proprioceptive drift towards the location of the rubber hand than typically developing adults (Paton, Hohwy, & Enticott, 2012).

These results are surprising when considered in conjunction with the idea that the physical self-concept remains intact in ASD as evidenced by the presence of intact mirror recognition (Ferrari & Matthews, 1983) and action monitoring (Grainger, Williams & Lind, 2013) abilities. This would imply that the presence of ASD should have no impact on performance on the RHI. However, there may be perceptual reasons for the weakening of the RHI effect seen in ASD which have very little to do with the sense of body ownership or the physical self-concept.

It is estimated that around 70% of people with ASD have some form of perceptual abnormality (Cascio, McGlone, Folgar, Tannen, Baranek, Pelphrey & Essick, 2008), which may contribute to performance on perceptual tasks such as the RHI. The autobiographies of high-functioning individuals with ASD often describe the world as being a confusing and over-stimulating place. The poor attentional control which is often seen in ASD means that it is difficult for those with the disorder to filter out extraneous background noise and focus on the important features of their environment. Instead, they may try to focus on everything at once, leading to an experience which is often described as one of confusion and terror (Frith, 2003). A commonly found visual abnormality is an extreme focus on small details of complex visual scenes. This is evidenced by an invulnerability to various visual illusions (Frith & Happe, 1994).

These abnormalities are not consistent from person to person; some people with ASD display hypersensitivity to certain sounds and types of tactile stimulation, while others display hyposensitivity to similar stimuli (for example, they may not appear to feel pain or to show the expected responses to particular sounds) (Kern et al, 2006).

Occasionally, the same individual may display both hypo- and hypersensitivity depending on the stimulus in question and the context in which it is encountered. This variation means that it is difficult to ascertain exactly what effect, if any, these perceptual abnormalities may have on performance on tasks such as the RHI. Having said this, we do know that people with ASD do not usually have hearing or visual impairments; it is rather that their perception of visual and auditory information may be unusual (Greenspan & Weider, 1997; O'Neill & Jones, 1997). Tactile perception in ASD also appears to be intact at a basic level as children with ASD are able to detect different grades of roughness of sandpaper as well as children without ASD (O'Riordan & Passetti, 2006) and are able to detect the presence of synthetic fibres placed against their skin (Cascio, McGlone, Folgar, Tannen, Baranek, Pelphrey & Essick, 2008). It seems unlikely therefore that relatively low-level sensory processing of this kind is interfering with performance on the RHI.

The sensory abnormalities seen in ASD are thought to be the result of downstream sensory processes. For example, information from different sensory modalities may not be integrated as quickly in people with ASD as it is in people without ASD. This could account for why it takes longer to create the RHI in people with ASD. This slower integration may stem from the fact that, people with ASD have a well-documented tendency to focus on specific details of a stimulus or event before focusing on the event or stimulus as a whole (Cascio et al, 2012). There is also evidence to suggest that people with ASD show a preference for proximal sensory information (touch, taste and smell)

over distal sensory information (sight and hearing) – for example, children with ASD often perform relatively poorly on purely visual tasks and will spend longer exploring tactile environments than visual ones (Masterton & Biederman, 1983). This is the opposite of the pattern seen in the general population (Cascio et al, 2012). As the RHI relies partly on the dominance of visual information over tactile information, this may account for the weaker RHI effect seen in participants with ASD.

In the current study, we intended to use the RHI to explore the idea of body ownership in ASD, rather than to investigate sensory abnormalities. As such, we included a ‘sham’ condition in which the rubber hand was replaced by a wooden block. This allowed us to directly compare performance on the wooden block and rubber hand conditions within each group (ASD and typically developing), rather than comparing performance across groups as it is likely, for the reasons outlined above, that the ASD group will be less susceptible to the RHI than the TD group. The ‘sham’ condition allows us to investigate body ownership specifically by examining the proprioceptive drift created by the rubber hand and the wooden block. We predict that the TD children will show a high level of proprioceptive drift in the rubber hand condition and little or no proprioceptive drift in the sham condition. If, as we have suggested, body ownership is intact in the ASD group, we would predict that the ASD group will show the same general pattern of results as the TD group even if the overall RHI is not as strong. In other words, children in the ASD group will still show some proprioceptive drift towards the rubber hand and little or no proprioceptive drift towards the wooden block as the wooden block does not look similar enough to a hand to be incorporated temporarily into the internal body representation. Experiment 4.1 was conducted with TD children only. This experiment was included as there has been little previous research into the RHI in children and it was felt that its presentation in a larger sample of TD children should be examined

before the task was used with children with ASD. Experiment 4.2 involved both children with ASD and TD children.

### **General Method: Experiment 4.1**

#### **Stimuli and Materials**

The rubber hand used approximated the size and appearance of the hand of an adult Caucasian female. The majority of our participants were male, but, to our knowledge, gender of the rubber hand has no effect on the illusion, with the majority of studies in this area employing ‘female’ rubber hands and participants of both genders with gender having no effect on results. Although no study has directly assessed the effects of the gender of the rubber hand, the RHI is surprisingly resilient and persists even under virtual reality conditions, (IJsselsteijn, de Kort, & Haans, 2006) leading us to conclude that the gender of the hand would have no effect here.. The rubber hand was detailed and lifelike, and was originally manufactured for use in the training of beauticians and manicurists.

The rubber hand was placed on a laminated number line on which its position and the position of the participant’s real left hand in each trial had been marked prior to the start of the experiment. In the neutral object condition, a wooden block was used in place of the rubber hand. The wooden block was of approximately the same size and shape as the hand. Tactile stimulation was applied to the participant’s hand, the rubber hand and the wooden block using the ends of two identical pens. The locations to which participants reached on the numberline were marked using stickers which were peeled off once the reaching locations had been measured.

#### **Procedure**

## **General procedure**

Participants were seated at a table in front of the laminated number line. The intended locations of the participant's hand, the rubber hand and the neutral object in each trial were marked on the number line prior to the beginning of the test session. The trial procedure is illustrated in figure 4.1. The test session began with several practice trials which were identical to the trials in the 'no hand' condition. These trials were included to ensure that the participants understood the relatively complex (given the age of the youngest participants) task instructions. The majority of participants completed two practice trials, although a small minority of the youngest participants ( $n = 4$  in experiment 4.1,  $n = 5$  in experiment 4.2, 3 ASD, 2 TD) required an additional practice trial before the experimenter was satisfied they had understood the task instructions.

Participants then completed the 'no hand' condition, 'hand condition', and 'neutral object' condition. Three experimental trials were included in each of the conditions and a standard counterbalancing procedure was employed, meaning that one third of participants completed the 'no hand' condition first, one third completed the 'hand' condition first and the remaining third completed the 'neutral object' condition first. This was intended to control for any potential effect of practice on task accuracy.

## **Control Condition**

Participants were seated in front of the numberline and were instructed to place their left hand beneath the table with their middle finger directly underneath the target location corresponding to the appropriate trial number marked on the numberline. They were told to make sure that their left hand was underneath the table, but was not touching the

table. They were asked to keep their right hand still and by their side. The experimenter stroked the participant's hand with the end of a pen for two minutes. The pen was moved from the base to the tip of the participant's middle finger. Whilst this was happening, the participant was instructed to look at the number line rather than at their hand. The purpose of the tactile stimulation here was simply to increase the similarity of the no hand condition to the other two conditions.

After two minutes, the pen was removed and participants were instructed to close their eyes and use their right hand to touch the place on the numberline which was directly above their left hand (they were instructed to 'make a hand sandwich' around the table). A sticker was then placed on the number line above the tip of the middle finger of their right hand. This procedure was repeated until the participant had successfully completed all three trials in the 'no hand' condition. Following the completion of the testing session, the experimenter measured the distance between each sticker and the target location in cm using a ruler.

### **Rubber Hand Condition**

Participants were again seated in front of the number line and instructed to place their left hand underneath the table, so that their middle finger was in line with the target location. Their right hand was by their side. The rubber hand was placed on top of the number line with its middle finger resting on a target location which was five centimetres away from the middle finger of the participant's left hand. On the first and last trial, the rubber hand was placed five centimetres to the left of the real hand and, on the second trial, it was placed five centimetres to the right. This was to try and prevent any practice effects. Additionally, the target location for the participant's hand and the

rubber hand were in a different position on the numberline for each of the three trials, again to lessen any potential effects of practice.

Once the rubber hand had been placed on the number line at the same orientation as the participant's real left hand under the table, participants were instructed to look at the rubber hand. Two identical pens were used to simultaneously stroke the middle fingers of the rubber hand and the participant's left hand. After two minutes the stroking was discontinued, the rubber hand was removed and participants were once again instructed to close their eyes and 'make the hand sandwich' around the table. Again, reaching position was marked by placing a sticker above the tip of the participants' right index finger. Following completion of the test session the distance from each sticker to both the target location and the location of the rubber hand was measured.

### **Neutral Object Condition**

The method employed here was identical to the method used in the rubber hand condition, except that the rubber hand was replaced with a wooden block of approximately the same size and shape. For one participant in the group with ASD, a toy car of approximately the same size was substituted for the wooden block at the request of the participant's mother after the participant became distressed by the appearance of the wooden block.

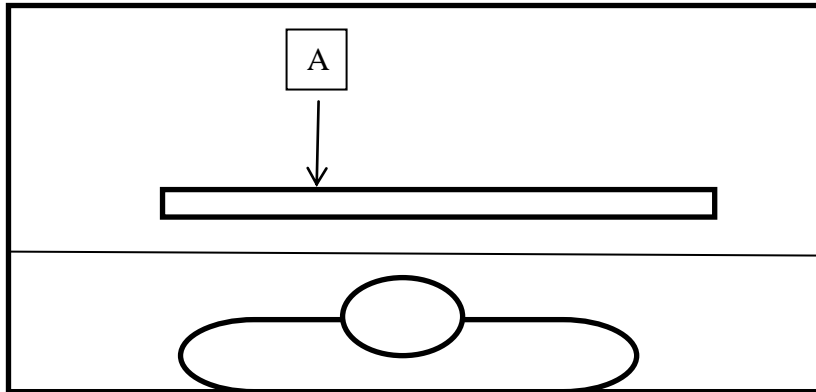
### **Scoring**

The raw data took the form of measurements (in cm) from the location of the participant's right hand to either the target location, the location of the rubber hand or the location of the neutral object. In total five measurements were taken; in the control condition, the distance from the right hand to the target location was measured, while in

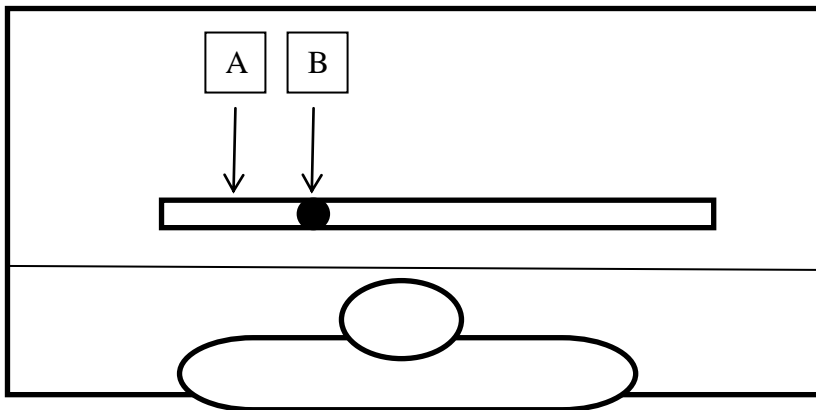
the rubber hand and neutral object conditions, the distance from the right hand to the target location was measured along with the distance from the right hand to the rubber hand/neutral object. Children who placed their right hands closer to the rubber hand/neutral object than to the target location (i.e. the left hand) were deemed to have shown significant proprioceptive drift towards the rubber hand/ neutral object and were considered to be vulnerable to the rubber hand illusion.



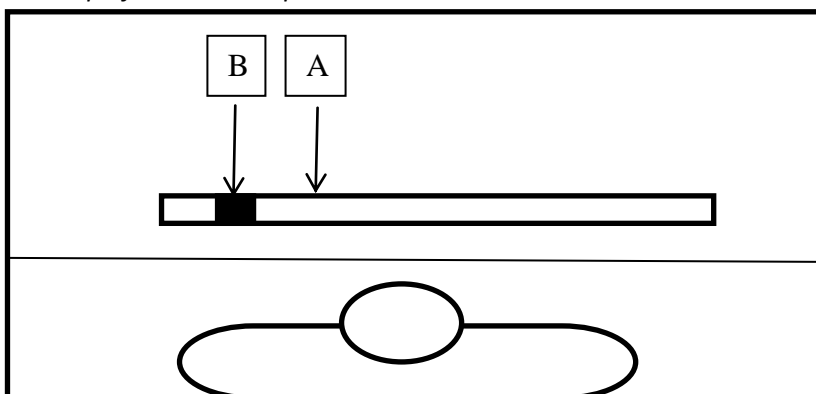
Figure 4.1. Trial set up in the control, rubber hand and neutral object conditions.



1. Control Condition. The child is seated in front of the number line. Their left hand is underneath the table at position A.



2. Rubber Hand Condition. The set-up is as before with the child's left hand underneath the table at position A and the rubber hand on top of the table at position B.



3. Neutral Object Condition. The child's hand is underneath the table at position A and the neutral object is on top of the table at position B.

## Participants

Participants were 20 children aged between 8 and 10 years, recruited through local primary schools and through staff working at Durham University. Twelve girls and 8 boys took part in the study (see table 4.1 for participant characteristics). In addition to the experimental task, all participants also completed a standard test of cognitive ability, the Wechsler Abbreviated Scales of Intelligence (Wechsler, 2008). None of the participants had any current or past diagnosis of autism spectrum disorder or any other developmental disorder. Participants were tested either at Durham University or in their schools. For approximately half of the testing sessions, a parent or teacher was present in addition to the experimenter. The study received ethical approval from Durham University's ethics committee. Participant characteristics are outlined in the table below.

**Table 4.1. Participant characteristics.**

	Minimum	Maximum	Mean	Standard Deviation
Age	8.0	10.0	9.19	0.87
Verbal IQ	84	145	114.95	19.43
Performance IQ	78	125	100.48	11.84
Full Scale IQ	84	138	107.76	15.94

## Results: Experiment 4.1

The raw data took the form of the distance of the participant's right hand from either their left hand, the rubber hand or the neutral object – the further away from their left hand they were, the greater the illusion. In the control condition, only one measurement is reported (distance from left hand), while in the rubber hand and neutral object

conditions two distances are reported (distance from left hand and distance from other object). Therefore, five distance scores are reported in total. As there were three trials in each condition, the raw data was used to calculate mean distance scores for each of the five measurements across the three conditions. This data is shown in the table below. All distances were calculated in centimetres.

**Table 4.2: Mean distance scores for experiment 4.1.**

<b>Condition</b>	<b>Measurement</b>	<b><i>M (cm)</i></b>	<b><i>sd.</i></b>
<b>Control</b>	<b>Distance from left hand</b>	0.75	0.60
<b>Rubber Hand</b>	<b>Distance from left hand</b>	2.03	1.19
	<b>Distance from rubber hand</b>	1.86	1.30
<b>Neutral object</b>	<b>Distance from left hand</b>	0.85	0.75
	<b>Distance from neutral object</b>	3.82	0.75

A repeated measures ANOVA with a within subjects factor of Condition and between subjects factors of Age and Gender was then conducted on the data. It was predicted that Age and Gender would have no effect on results, but they were included in the analysis to ensure that any effect of condition was dependent upon Condition alone and was not affected by Age or Gender. The analysis revealed a significant main effect of Condition,  $F(4,56) = 20.69, p < .001, \eta^2 = .60$ , which will be explored in more detail below. The effects of Age,  $F(2,14) = 3.27, p = .07, \eta^2 = .32$ , and Gender,  $F(1,14) = 1.16, p = .29, \eta^2 = .08$ , were both non-significant. The interaction effects of Age and

Condition,  $F(8,56) = .85, p = .56, \eta^2 = .12$ , Gender and Condition,  $F(4,56) = .83, p = .51, \eta^2 = .06$ , and Gender, Age and Condition,  $F(8,56) = 1.12, p = .36, \eta^2 = .14$ , were also non-significant. As Age and Gender generated no significant main effects or interaction effects, they will not be included in any further analyses.

In order to further explore the effect of condition (each of the five measurements detailed above) on hand position, a series of paired sample t-tests was conducted. In the Neutral Object condition, there was a significant difference between the distance from the left hand and the distance from the wooden block,  $t(19) = 11.66, p < .001$ , Cohen's  $d = -3.96$ . This reflects the fact that the mean distance from the plastic block is far greater than the mean distance from the left hand. This implies that there was no significant proprioceptive drift towards the wooden block in the Neutral Object condition. In other words, the presence of the wooden block did not induce the RHI. There was also no significant difference between the distance measurement in the no hand condition and the distance from the left hand in the Neutral Object condition,  $t(19) = .49, p = .63$ , Cohen's  $d = 0.15$ . Taken together, these results imply that the presence of the wooden block did not interfere with the processing of the location of the left hand. In other words, children's responses were not altered by the presence or absence of the woodenblock.

In the Rubber Hand condition, there was no significant difference between the distance from the left hand and the distance from the rubber hand,  $t(19) = .32, p = .75$ , Cohen's  $d = 0.14$ . The implication here is that children were placing their right hands approximately halfway between their left hand and the rubber hand – in other words, there was significant proprioceptive drift towards the rubber hand. There was, however, a significant difference between the distance measurement in the no hand condition and

the distance measurement from the left hand in the Rubber Hand condition,  $t(19) = 3.89$ ,  $p = .001$ , Cohen's  $d = -1.36$ . This again suggests that the presence of the rubber hand interfered to a significant degree with locating the left hand in space.

A categorical analysis of the data was then carried out on the data from the Rubber Hand and Neutral Object conditions. Distance from the left hand in each condition was subtracted from the distance from the rubber hand or wooden block. Values of less than zero indicted the presence of proprioceptive drift as these were the cases where the right hand had been placed closer to the rubber hand or wooden block than to the left hand. In the Rubber Hand condition 11 of the 20 children placed their right hand closer to the rubber hand than to their left hand, while, in the Neutral Object condition, this proprioceptive drift was absent and no child placed their right hand closer to the wooden block than to their left hand. McNemar's test revealed that there was a significant difference in proprioceptive drift between the rubber hand and neutral object conditions,  $p = .03$ . This again provides evidence for vulnerability to the rubber hand illusion. Table 4.3 Provides a breakdown of the categorical data, detailing the degree of proprioceptive drift present.

**Table 4.3. Breakdown of categorical analysis**

Condition	Relative positions of right and left hands (cm)*								
	-4 -- 3.1	-3 -- 2.1	-2 -- 1.1	-1.1 - 0	0 - +1	+1.1 - 2	+2.1 -3	+3.1 - 4	+4 or more
Rubber hand	2	4	4	1	3	3	1	2	0
Neutral object	0	0	0	0	1	4	4	10	2

\*scores of 0 indicate that the right and left hands were in the same position. Negative scores indicate proprioceptive drift towards the rubber hand/neutral object, while positive scores indicate the absence of proprioceptive drift.

## Discussion: Experiment 4.1

The results of experiment 4.1 were as expected. All the children were successfully able to use their left hands to locate their right hands reliably in the absence of conflicting visual information in the no hand condition. The children showed a strong proprioceptive drift towards the rubber hand in the Rubber Hand condition, with the left hand being placed, in the majority of cases, almost equidistant between the rubber hand and the right hand. In the sham Neutral Object condition, the presence of the wooden block had no effect on performance and results here were almost identical to those observed in the no hand condition.

These results are in line with those of earlier studies. Results from the Rubber Hand condition do indeed imply that the rubber hand becomes temporarily incorporated into the mental body representation or physical self-concept of the participant during the RHI (Kammers, deVignemont, Verhagen & Dijkermann, 2009). These results also provide support for the idea that the RHI can be induced after a relatively short period of synchronous stroking (Pavani, Spence, & Driver, 2000).

The results from the sham condition are also in line with those found in previous studies. A large body of work exists which suggests that participants cease to be vulnerable to the RHI if the rubber hand is placed in an anatomically implausible position or a position which is non-congruent to the position of the real body part (Llobera, Sanchez-Vives, & Slater, 2013; Constantini & Haggard, 2005). The Illusion also fails when the rubber hand is replaced with another object of a similar size and shape as it was here (Pavani, Spence & Driver, 2000). Such a 'sham' does not share enough visual similarities with a real body part to be incorporated even temporarily into the physical self-concept.

There has been relatively little research into the RHI in children which makes these results especially interesting. Damon and Hart (1991) and others have proposed that the physical self-concept is almost fully developed by the age of 7 years. In light of this, it is unsurprising that the children who took part in this experiment were all susceptible to the RHI as they were all aged 8 or above.

### **Method: Experiment 4.2**

The procedure employed in experiment 4.2 was identical to that used in experiment 4.1. Participants in experiment 4.2 consisted of 12 children with a current diagnosis of autism spectrum disorder aged between 7 and 10 (1 female, 11 male) and 12 typically developing children (4 female, 8 male) matched to the group with ASD in terms of gender, age, and IQ (see table 4.3 for participant characteristics). Participants in the TD group had no current or past diagnosis of any developmental disorders and all scored below the clinical cut-off for ASD on the social responsiveness scale (Constantino, 2012). Participants were recruited through local schools and through email advertisements sent out to university students and staff.

All participants in the group with ASD had received a formal diagnosis of autism spectrum disorder or Asperger's Syndrome. All diagnostic information was checked rigorously. 11 of the 12 participants with ASD also scored above the cut-off for clinical ASD on the SRS-2. The remaining participant had a current diagnosis of ASD and attended a specialist school for children with ASD. Participant characteristics are shown in the table below.

**Table 4.4. Participant characteristics.**

	ASD Group		TD Group		Group Comparisons		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>	Cohen's <i>d</i>
<b>Age</b>	8.91	0.79	9.0	0.60	0.27	.80	0.13
<b>VIQ</b>	111.90	14.90	112.83	15.07	0.21	.84	0.10
<b>PIQ</b>	108.41	16.63	104.84	16.61	0.55	.59	0.25
<b>FSIQ</b>	110.63	15.48	108.33	15.56	0.22	.83	0.10
<b>SRS</b>	80.11	12.57	48.??	7.21	10.29	.00	3.86

### Results: Experiment 4.2

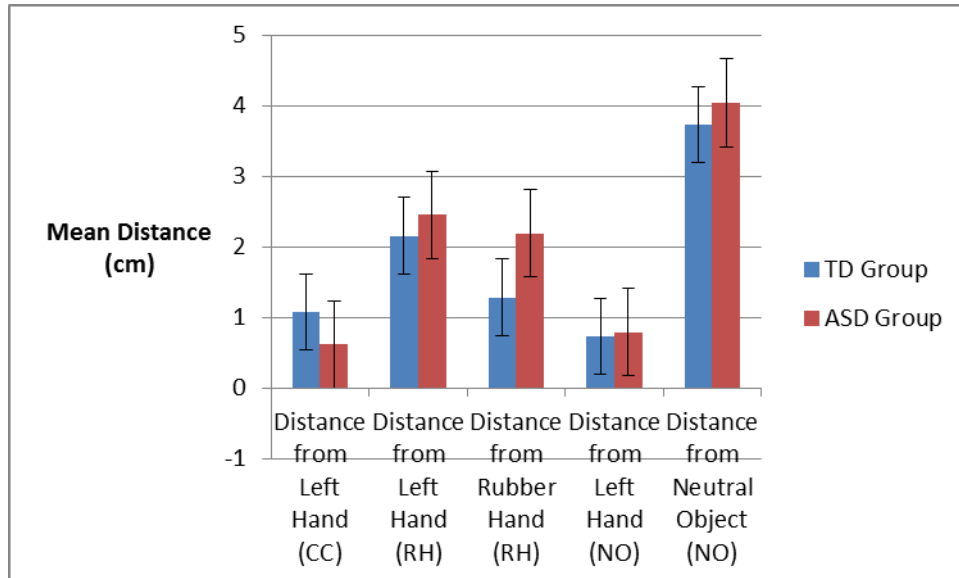
The raw data were again used to calculate mean scores for each of the five measurements. These are shown in the table below. Data from the typically developing (TD) group and ASD group is presented separately. The data is also presented in figure 4.1.

**Table 4.5. Mean distance scores for the ASD and TD groups.**

Condition	Measurement	TD Group		ASD Group	
		<i>M (cm)</i>	<i>SD</i>	<i>M (cm)</i>	<i>SD</i>
<b>Control</b>	Distance from left hand	1.08	1.25	0.61	0.57
<b>Rubber Hand</b>	Distance from left hand	2.17	.94	2.45	1.57
	Distance from rubber hand	1.28	1.06	2.19	1.48
	Distance from left hand	0.73	0.81	0.79	0.95
<b>Neutral Object</b>	Distance from neutral object	3.73	0.85	3.83	1.18



Figure 4.2. Mean distance in each condition. Error bars represent standard error (1 SEM).



A repeated measures ANOVA with a within subjects factor of Condition and a between subjects factor of Group was carried out to assess the effect of experimental condition on hand position. There was a significant main effect of Condition,  $F(4,88) = 28.67, p < .001, \eta^2 = .57$ , which will be explored in more detail below. The main effect of Group was non-significant,  $F(1,22) = .99, p = .33, \eta^2 = .04$ , and the interaction effect of Group and Condition was also non-significant,  $F(4,88) = 1.13, p = .35, \eta^2 = .05$ .

A series of t-tests was conducted on the data to further explore the effect of condition on hand position. It was found that there was a significant difference between the mean distance from the wooden block and the mean distance from the left hand in the Neutral Object condition,  $t(23) = 9.10, p < .001$  Cohen's  $d = -3.17$ . This reflects the fact that the mean distance from the wooden block ( $M = 3.78, SD = .02$ ) is far greater than the mean distance from the left hand ( $M = .76, sd = .88$ ). There was no significant difference

between the distance from the left hand in the Neutral Object and no hand conditions,  $t(23) = .45, p = .65$ , Cohen's  $d = 0.10$ . This pattern of results is identical to that observed in experiment 4.1.

In the Rubber Hand condition, there was no significant difference between the distance from the left hand and the distance from the rubber hand,  $t(23) = 1.20, p = .24$ , Cohen's  $d = .45$ . There was, however, a significant difference between the distance from the left hand in the no hand and Rubber Hand conditions,  $t(23) = 5.00, p < .001$ , Cohen's  $d = -1.33$ . Again, this is identical to the pattern of results seen in experiment 4.1.

Categorical analysis of the data indicated that one of the children in each group showed very slight proprioceptive drift towards the woodenblock, where proprioceptive drift was defined as the placing of the right hand closer to the wooden block than to the left hand. However, 10 out of the 12 children in the TD group and 7 out of the 12 children in the ASD group demonstrated proprioceptive drift towards the rubber hand. A chi squared test demonstrated that the performance of the two groups was not significantly different,  $\chi^2 (1, n = 12) = 1.82, p = .18, \Phi = .37$ . Table 4.6 provides a breakdown of this categorical analysis.

**Table 4.6. Breakdown of categorical analysis**

Condition	Group	Relative positions of right and left hands (cm)*								
		-4 -- 3.1	-3 -- 2.1	-2 -- 1.1	-1.1 - 0	0 - +1	+1.1 - 2	+2.1 - 3	+3.1 - 4	+4 or more
Rubber hand	ASD	0	3	2	2	1	0	2	2	0
	TD	0	3	2	5	0	0	2	0	0
Neutral object	ASD	0	0	1	0	1	0	0	7	3
	TD	0	0	0	1	0	1	4	1	5

\*scores of 0 indicate that the right and left hands were in the same position. Negative scores indicate proprioceptive drift towards the rubber hand/neutral object, while positive scores indicate the absence of proprioceptive drift.

## **Discussion: Experiment 4.2**

Previous research (Cascio, Foss-Feig, Burnette, Heacock & Cosby, 2012; Paton, Hohwy & Enticott, 2012) into the RHI in ASD suggests that children and adults with ASD are vulnerable to the RHI, but may be less vulnerable to it than their typically developing peers. For example, they may take longer to incorporate the rubber hand into their internal body representation scheme and they may experience less proprioceptive drift towards the rubber hand.

Our results were broadly in line with these findings. The TD group in experiment 4.2 showed the same pattern of responses as the TD group in experiment 4.1. The results of the ASD group in experiment 4.2 were nearly indistinguishable from those of the two TD groups. The ASD group were susceptible to the RHI, but there is evidence that they may have been slightly less susceptible to the illusion than the TD group. In particular, the categorical analysis of the data revealed that 10 out of the 12 TD children were strongly affected by the RHI and showed a high level of proprioceptive drift towards the rubber hand (where a high level of proprioceptive drift was defined as placing the right hand closer to the rubber hand than to the left hand). In the ASD group, while the mean proprioceptive drift towards the rubber hand was greater than in the TD group, only 7 out of the 12 children showed the significant levels of proprioceptive drift. Thus, a greater number of children in the ASD group experienced no significant proprioceptive drift. This is in keeping with the idea that children with ASD may take longer to experience the RHI and may, in some cases, experience less pronounced proprioceptive drift. Despite this, the difference in performance between the two groups remained non-significant.

The fact that some individuals with ASD appear to experience the RHI very strongly may provide support for the idea that those who do not fail to experience it because of a visual processing deficit or a deficit of sensory integration, rather than because of an impairment in the physical self-concept, since an impairment in the physical self-concept would be likely to persist across the majority of individuals with ASD, while sensory deficits vary widely from individual to individual. While not definitive proof that the physical self-concept is unimpaired in ASD, the results of this experiment provide compelling evidence that this may be the case.

### **General Discussion**

The aim of experiment 4.1 was to provide a set of baseline data against which to compare the results of the group with ASD in experiment 4.2. A secondary aim was to further the understanding of the rubber hand illusion (RHI) in children. Experiment 4.2 was intended to examine the strength of the physical self-concept in children with ASD. It has been suggested that the physical self-concept in children with ASD is largely intact, while the psychological self-concept is somewhat impaired. If this is the case, then we would predict that children with ASD would perform at the level of their TD peers on this task. In other words, they would have a strong mental representation of their physical bodies and would therefore be vulnerable to the RHI. Their performance should not be affected by the presence of the wooden block since this looks sufficiently different from a hand that it should not be incorporated, even temporarily, into the mental representation of the body.

The results were largely as predicted. The TD group showed significant proprioceptive drift towards the rubber hand and no proprioceptive drift towards the wooden block. This demonstrates that the physical self-concept is strong enough, by the age of eight

years, to incorporate into the mental representation of the body objects which are plausible (i.e. similar in size, shape and appearance to various parts of the body), but not objects which are implausible (i.e. different in size, shape and appearance). Although the RHI has only rarely been conducted with children, these results were as expected since Damon and Hart (1991) and others have demonstrated through various interview studies that the physical self-concept is fairly fully developed before the age of 8.

It was predicted that the group with ASD would show the same pattern of responses as the TD group. In general, this was the case; no proprioceptive drift occurred in response to the neutral object and significant proprioceptive drift occurred in response to the rubber hand, among both groups. Fewer children in the group with ASD showed a high level of proprioceptive drift (when a high level was defined as placing the left hand closer to the rubber hand than to the right hand). However, the difference between groups was not significant. This finding contradicts somewhat the findings of Cascio, Foss-Feig, Burnette, Heacock and Cosby (2012), and Paton, Hohwy and Enticott (2012) who found that people with ASD showed less vulnerability to the RHI than others and had to be exposed to the rubber hand for a longer duration than a control group in order to experience the effect. However, it should be noted that Cascio, Foss-Feig, Burnette, Heacock and Cosby (2012) employed an asynchronous stroking condition, rather than a Neutral Object condition. These differences in methodology mean that it is difficult to draw a direct comparison between their results and the results reported here. Paton, Hohwy and Enticott (2012) also employed an asynchronous stroking condition and incorporated a condition in which participants wore goggles which altered their perception of where the rubber hand was in space. This again means that it is potentially difficult to directly compare our methodology with theirs.

The most important finding here is that the RHI is successful in children with ASD. The success of the RHI depends upon the rubber hand being temporarily incorporated into an individual's physical self-concept and, in order to do this, the physical self-concept has to be very well developed. The individual in question must have an accurate visual internal representation of their own body parts and must also have an idea of where they are in space. Without these representations, the presence of a neutral object such as a wooden block should generate exactly the same pattern of proprioceptive drift as the presence of the rubber hand. That this did not happen in the group with ASD can be taken as compelling evidence that the physical self-concept in ASD is present and fairly sophisticated. Any differences in performance in the rubber hand condition between the ASD and TD groups may be due to sensory processing abnormalities in the ASD group and cannot be taken as evidence that the physical self-concept is somehow weaker or less developed than that of the TD group.

These results are consistent with other evidence suggesting that the physical self-concept is relatively unimpaired in ASD. For example, people with ASD are able to recognise themselves in mirrors (Ferrari & Matthews, 1983), are successful at delayed video recognition of themselves (Lind & Bowler, 2009), and can discriminate between self and other caused changes in their environments (Williams & Happe, 2009). Taken together, these results, as well as their performance on the rubber hand illusion provide compelling evidence that the physical self-concept is largely intact in ASD.

Having established something about the state of the physical self-concept in ASD, the following two chapters are intended to further compare and contrast the physical and psychological self-concepts in adults and children with ASD. We wanted to develop a fuller picture of the way in which people with ASD perceive the self both in the present

and in the domain of memory. In order to do this we came up with an interview task (chapter 5) for use with adults and a statement completion task (chapter 6) for use with children.

## **Chapter Five: Dimensions of the Self in Autobiographical Memory in Autism Spectrum Disorder**

Previous chapters have outlined evidence for an intact physical self-concept and an impaired psychological self-concept in children and adults with ASD. However, all the evidence presented so far has been gathered using quantitative methodologies. The current chapter and the one following it aim to gain an insight into the physical and psychological self-concepts of people with ASD using mixed methodologies which have a qualitative element. These kinds of methods were used as they are somewhat less prescriptive than purely quantitative methodologies and allow participants a greater freedom of response. It was hoped that this would give us a more rounded, ‘first person’ picture of the quality of internal self-representations in people with ASD. Before going into details of the methodology used, I will briefly re-cap the evidence from previous studies which have utilised similar methods in populations with ASD and typically developing children.

In children and adults with ASD, it is thought that the shift from a predominantly physical to a predominantly psychological self-concept is impaired. There is a considerable amount of evidence for this (discussed elsewhere in this thesis), but of particular relevance here is evidence from Lee and Hobson (1998) who conducted Damon and Hart’s (1991) self-understanding interview with a group of adolescents with ASD. They found that adolescents with ASD gave comparable answers to their typically developing peers on questions to do with physical aspects of the self. The sheer number of statements produced about the self by the ASD group did not differ significantly from the number of statements produced by an age-matched TD group. However, the types of statements did differ; the group with ASD generated far fewer psychological



statements and, those they did generate, were fairly generic and had something of a learned feel (for example, descriptions were often general and included non-specific words such as 'nice' and 'good'). This study was replicated with a larger sample by Farley, Lopez and Saunders (2010). They found similar results to Lee & Hobson (1998) and also found that the group with ASD viewed personality as being something which is stable over time while the TD group saw it as something which would change.

In an attempt to gain a more rounded picture of the inner life of people with ASD, Hurlburt, Happe, and Frith (1994) used experience-sampling with three adults with Asperger Syndrome. Their participants were given a bleeper set to go off at random intervals during a set period of time. Each time the bleeper went off, participants would have to write down everything they were thinking and feeling. They were then interviewed about these 'experiences'. It was found that the majority of their inner experience was visual in nature. This was in sharp contrast to the TD group who reported a range of different inner experiences. The group with ASD also gave less detailed responses overall. It may be that the group with ASD failed to introspect as much about their own thoughts, feelings, cognitions and mental states as the TD group which could be evidence of an impaired psychological self-concept.

Interestingly, the level of inner experience reported was correlated with the level of false belief tasks participants could pass. Participants who failed simple, first order false belief tasks displayed reduced ability to reflect upon inner experience compared to those who passed first order false belief tasks. This links in neatly with the Theory of Mind account of ASD which suggests that people with ASD lack theory of mind (an understanding of the mental states and beliefs of self and others). Therefore, impairments in theory of mind could arguably be a consequence of an impaired

psychological self-concept. This would mean that the numerous accounts of poor performance on Theory of Mind tasks (Wimmer & Perner, 1983; Baron-Cohen, 1985) found in the ASD literature could be seen as evidence for an impaired psychological self-concept.

Much of the more qualitative research into the psychological self-concept in ASD has focused on investigations of the types of social relationships people with ASD form with those around them. Simulation Theory (Goldman, 1992) is based around the idea that we use our own mental states, beliefs and desires as a model for understanding the mental states of those around us. This understanding then allows us to form social relationships with others. Evidence that such relationships are absent or lessened in ASD is irrefutable. For example, people with ASD are often unable to define what a friend is (Hobson, 1995). They are also often less able or less willing than neurotypical individuals to imitate others (Rogers, 1999). Simulation theory would suggest that these features of ASD may stem from an impaired psychological self-concept or, at the very least, an impairment in the way in which information about the self is used as a template for an understanding of the thoughts, feelings and mental states of others. What is perhaps unclear is the direction of causation here; an impaired psychological self-concept may cause impairments in social interaction, but equally a lack of social contact caused by impairments in social interaction may lead to an impaired psychological self-concept.

Central to the psychological self-concept is the idea of autobiographical memory. It has been suggested that autobiographical memory does not emerge fully until the self-concept is fairly developed as autobiographical memory is structured around the self (Howe & Courage, 1997). Autobiographical memory is implicated in key areas of social

functioning such as aiding in the solving of social problems (Goddard, Dritschel & Burton, 1996), in the formation and maintenance of social relationships (Pillemer, 1992) and in providing information for social communication and interaction (Cohen, 1989). As these functions are impaired in ASD, it might be that some impairment of autobiographical memory is also present.

There is a growing body of evidence that this is the case. Children with ASD remembered fewer activities (such as playing with a ball) after delays of a few minutes (Boucher, 1981) and several months (Boucher & Lewis, 1989) than children without ASD. These memory impairments appear to persist into adulthood; Goddard et al (2007) asked adults with ASD to generate autobiographical memories in response to specific cue words. It was found that adults with ASD generated fewer memories than TD adults. The memories generated were also somewhat less specific.

There also seem to be differences in the way in which people with ASD and people without ASD encode information in memory. In particular, in TD individuals, the type of information presented has an effect on how well it is later remembered, whereas in individuals with ASD, the type of information appears to have less of an effect. For example, children with ASD show no memory advantage for meaningful over meaningless information (Hermelin & Frith, 1991). It had been suggested that this is because a remember/know distinction exists within ASD. People with ASD appear to 'know' things without 'remembering' them. In other words, information is recalled independent of context. Bowler, Gardiner and Berthollier (2001) found that adults with ASD were able to memorise lists of words as well as adults without ASD, but they were unable to recall much of the contextual information which had been presented along with the word lists. In a related experiment, Millward, Powell, Messer and Jordan

(2000) found that adults with ASD showed no memory advantage for events which had been personally experienced as opposed to events which had been experienced by another. Again, this seems to be evidence of context independent memory. As context is necessary for episodic autobiographical memories to form, context independent memory would lead to deficits in this area.

Further support for the idea that memory impairments in ASD are specific to episodic memory comes from the fact that semantic memory (memory for facts) appears to be something of a strength in ASD. For example, a case study of RJ, a young man with ASD, indicated that he had accurate knowledge of his own personality traits, but he could not recall the events on which this knowledge was based (Klein, Chan & Loftus, 1999). Crane and Goddard (2008) asked adults with ASD to describe certain key events in their lives (for example their first day at school) with a focus on either episodic details or semantic details (such as the teacher's name). The adults with ASD were unimpaired at recalling semantic details, but had more difficulty recalling episodic details.

The current study builds on the work of Goddard et al (2007) by asking adults with ASD to generate specific memories in response to various cue words intended to trigger memories which were either physical (e.g. being hungry) or psychological (e.g. concentrating on something) in nature. The aim of this was firstly to assess the quantity and quality of memories produced and, secondly, to examine any differences between the physical and psychological memories generated. It was predicted that the ASD group would generate fewer and less specific memories than the TD group in general, but that physical memories in the ASD group would be more detailed and specific than memories generated in response to psychological cue words. This difference between

the quality and specificity of physical and psychological memories was not expected to occur in the TD group.

### **Method: Experiment 5.1**

#### **Participants**

Fifteen adults with ASD (3 female) and 15 typically developing comparison adults (4 female) took part in this experiment, after giving written, informed consent. Participants were recruited from an existing database of participants who had previously taken part in studies conducted by the Autism Research Team at Durham University, and who had agreed to be contacted about future research projects. All participants received financial compensation for their participation. Participants in the ASD group had all received formal diagnoses of autistic spectrum disorder ( $n = 12$ ) or Asperger's disorder ( $n = 4$ ), according to conventional criteria (American Psychiatric Association, 2000).

Diagnostic information was checked thoroughly to ensure diagnoses were rigorous and current. In addition to these diagnoses, severity of current ASD features was assessed with the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000). This measure was used with participants in the ASD group only. Two participants declined to complete it for personal reasons. Consistent with their formal diagnoses, all participants with ASD who consented to taking part in the ADOS scored above the ASD cut-off ( $\geq 7$  points) on this measure. The two participants who declined to complete the ADOS scored above the ASD cut-offs on the Autism Quotient (AQ), a self-report measure designed to measure levels of autism like traits (Baron-Cohen, Wheelwright, Skinner, Martin & Clubley, 2001).

The AQ was administered to both participants in the ASD group and comparison participants in order to ensure that comparison participants did not display ASD-like

symptoms and traits. As expected, all comparison participants scored below the ASD cut-offs on the AQ (< 26 points). A small minority of participants with ASD (n = 2) scored below the cut-off for ASD on the AQ. These two participants scores above the ASD cut-offs on the ADOS.

Verbal and non-verbal ability of both groups was assessed using the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 2008). This allowed the two groups to be matched as closely as possible for both verbal and non-verbal ability. The groups were also matched closely for chronological age. Importantly, all effect sizes associated with group differences in baseline characteristics of age and IQ were negligible (see table 5.1 for group comparisons). This study received ethical approval from Durham University ethics committee. Participant characteristics are presented in Table 5.1.

**Table 5.1 Participant Characteristics**

	TD Group		ASD Group		Group Comparisons		
	<i>M</i>	<i>sd</i>	<i>M</i>	<i>sd</i>	<i>t</i>	<i>p</i>	Cohen's <i>d</i>
<b>Age</b>	29.80	12.60	30.12	10.67	0.79	.94	0.03
<b>P-IQ</b>	115.00	9.35	113.14	15.16	0.20	.85	0.15
<b>V-IQ</b>	117.53	10.51	110.00	14.95	1.45	.17	0.58
<b>FS-IQ</b>	118.40	10.44	112.40	15.54	1.12	.28	0.45
<b>AQ*</b>	11.07	5.57	34.33	9.96	7.41	<.001	3.55

*\*The range of AQ scores for the group with ASD was 14 – 44 and the range of AQ scores for the TD group was 3 – 22.*

## **Materials and Procedure**

### **Task Outline.**

The task took the form of an interview in which participants were asked to generate two self-referential memories in response to a cue word. Each cue word related to a specific mental or physical state. Two memories were generated, for each cue word to reduce the likelihood of stereotyped responses.

### **Selection of stimuli and task design.**

Sixteen cue words were selected, each describing either a mental or a physical state. Eight of the words selected related to physical states and 8 related to mental states, but not emotions. The decision not to use words relating to emotions was made because it has already been well-documented that people with autism display the alexithymia construct and, thus, find it difficult to identify and describe their own emotional states (Heaton, Reichenbacher, Souter, Allen, Scott & Hill, 2012). The list of physical state words and the list of mental state words were matched as far as possible in terms of written and verbal frequencies, however, exact matching proved impossible due to a lack of suitable words describing physical states. The 16 cue words used were ‘pain’, ‘ill’, ‘tired’, ‘cold’, ‘hot’, ‘hungry’, ‘nauseous’ and ‘thirsty’ (physical states) and ‘want’, ‘pretend’, ‘guess’, ‘know’, ‘forget’, ‘understand’, ‘predict’ and ‘concentrate’ (mental states).

### **Procedure.**

Participants were presented with cue words and asked to describe two memories relating to each. Each cue word was presented in the context of a question, for example ‘*can you tell me about a time when you’ve felt hungry?*’. It was stressed that the memories should be specific and detailed and an example of a suitably detailed answer was given. A time

limit of one minute was set for each memory and the entire interview took approximately half an hour.

## **Coding of Responses**

### **General outline of coding scheme.**

Interview data was analysed for its level of detail, specificity and level of physical vs psychological descriptions. The length of each answer (number of words) was also noted. When analysing interview data, a coding scheme based on that of Levine et al (2002) was used, with some significant additions and differences. These changes were made as the aim of the current study and the content of the memories being described were considerably different to those in Levine's original study (see further details below).

### **Central and peripheral details.**

Each memory was initially segmented into 'bits' of information, with each 'bit' comprising one specific detail. In general, details took the form of one grammatical clause (subject, verb and predicate) which was used to describe a particular occurrence, observation, thought or emotion. An example of such a 'bit' would be '*I walked my dog.*' In some cases, clauses contained several additional details, in which case, each detail was coded separately. For example, the sentence, '*I walked my dog in Salisbury last Wednesday*', contains three details; an event (walking the dog), a location (Salisbury) and a time (last Wednesday).

The details in each description were grouped into central details and peripheral details, with central details being those which are directly relevant to the main event being described in the memory. Peripheral details are those which relate to all other parts of



the description. In cases where the main event was unclear or vague (e.g. in cases where more than one event was described or events are described in general rather than specific terms), the main event was considered to be an event about which several details were given and which occurred in a time frame of half a day or less. In cases where more than one event fit this criteria then the event about which the greatest number of details was given was considered to be the main event.

### **Categorization of central details.**

Levine's (2002) original coding scheme divided central details up into five categories; events, places, time references, perceptual details, and emotions/thoughts. Three of these categories (events, places, and time references) are used here. The 'emotions/thoughts' category has here been divided into two categories namely, 'emotions' and 'thoughts'. Similarly the perceptual details category has been subdivided into separate categories for 'perceptual details' and 'external details' (the distinction between these categories will be outlined later). The current coding scheme differs further from that of Levine et al as, in addition to these central details, the presence of people (or personified animals) within a memory was also noted and coded for in a 'person/animal present' category. Two additional categories were also included for the purpose of coding descriptions of the thoughts and actions of others.

Central details therefore were placed into one of ten categories, namely events, places, time references, perceptual details, external details, emotions, thoughts, person/animal present, thoughts of others and actions of others. The emotions category deals only with expressions of direct emotion such as '*I remember being very happy*', while the thoughts category is restricted to psychological details and opinions (for example, an expression of revulsion towards a particular food). Both the external details category

and the perceptual details category refer to physical descriptions, but they differ in that, the external details category is concerned with general physical details which do not directly involve the agent, while the perceptual details category is concerned with more ‘first person’ physical descriptions which encompass the actions and perceptions of the agent. For example, a phrase such as *‘the mountains were steep and rugged’* would be coded as an external detail, while the phrase *‘the path I was walking on seemed very steep’* would be coded as a perceptual detail.

### **Peripheral details.**

Details considered to be peripheral were divided up into semantic details (background factual information, for example *‘Salisbury is a small city.’*), physical details of more general autobiographical memories, not related to the main event, psychological details not related to the main event and repetitions. Again, the inclusion of physical and psychological details here is a departure from Levine’s (2002) original coding scheme. An example of the coding scheme is included below.

*Figure 5.1: Example of the coding scheme in use.*

Time	Event	Animal	Time
	<i>‘the first time I rode a horse, I must have been about six years old. It was the</i>		
Time	External detail		
	<i>middle of the summer, one of those scorching, blistering days where</i>		
External detail		Animal	
	<i>everything seems to have been stilled by the heat and even the birds are silent.</i>		
Place	External detail		Perceptual detail
	<i>The riding school was outdoors and it was huge, or at least it seemed huge at</i>		
External detail			Repetition

*the time. It was filled with dust and heat and the smell of horses. I rode the*

### **Perceptual Detail**

### **Perceptual detail**

*horse around the outside of it. I was riding a little strawberry roan pony*

### **Thought**

### **Thought**

### **Peripheral detail (psy)**

*called Fairy. She was very gentle and quiet and, over the years, we reached a*

### **Peripheral detail (psy)**

### **Repetition**

*kind of understanding. Riding her became intuitive almost, but that first time*

### **Perceptual detail**

### **Event**

### **Person**

*it wasn't. I had the sense of being very high up and of looking down at people*

### **Thought**

*which isn't a thing which usually happens when you're six – and of feeling*

### **Perceptual detail**

### **Emotion**

### **Emotion**

*unsteady. But, at the same time, I was happy. I felt very free.*

## **Analysis.**

Following coding, details from each category were tallied and summed to give central and peripheral 'scores'. Levels of detail in each particular category were also compared between participant groups and between cue word types (physical/ psychological). Length of utterance was measured simply by counting the number of words used to describe each memory.

## **Richness Ratings.**

Finally, 'richness' ratings were assigned to each memory. These ratings are concerned with episodic richness in terms of details of time, place, emotions and thoughts and also reflect the degree of specificity of each memory. The highest rating of 3 was assigned to

descriptions of memories which were rich, highly-specific, evocative and vivid and which seem to evoke a feeling of re-experiencing the event in question. Ratings of 2 were given where the richness necessary to evoke a rating of 3 was absent. Descriptions which received a rating of 1 were general and non-specific and ratings of 0 were given to those descriptions which were based on semantic knowledge, rather than episodic memory or which were highly general in nature. Figure 5.2 gives examples of these different ratings.

*Figure 5.2: Richness ratings for various descriptions of the same event.*

Rating of 0

*'Squash is a great game. You always feel really energized after playing, like you're ready to go and conquer the world. I've played it for a long time and I've always enjoyed it. I play tennis too, but squash is much better – the court is a more manageable size and it's just faster as a game, more exciting.'*

Rating of 1

*'I love to play squash. I learnt how to play in sixth form. At my school, you had to do sport in sixth form even if you weren't doing PE A-level, but you could choose which sport you wanted to play out of this huge list. My friend, Vicky, and I chose squash just because we'd never played it before and it sounded fun. We had lessons for a couple of years at school and, even, after we left school, we carried on playing together a few times a week.'*

Rating of 2

*'My friend, Vicky, and I used to get very competitive over squash. We were very evenly matched and you could never tell, at the beginning of the game, who was going to win. There was this one time when we played about six games in a row, without stopping and, in the end, we won three each. We ended up just sitting on the floor of the squash*

*court, feeling completely exhausted and laughing about how neither of us ever managed to win properly.'*

### Rating of 3

*'I remember this one fiercely competitive squash game I played with my friend, Vicky. We were in sixth form and we had a lot of coursework deadlines and we'd just started doing exam revision, so we were both a bit stressed and I think we took out all that stress on the squash court. We played about six games. I remember that each game was faster than the last and I remember feeling exhausted. My legs were heavy and it was hard to run by the end of it. I could see that Vicky was getting tired too, but we were both stubborn and neither of us wanted to be the first one to stop, so we just kept playing. The racquet started to feel like a lead weight in my hand, but still I didn't think about stopping. The game finally ended when I hit the ball so hard that it bounced off the ceiling and got stuck in one of the light fittings. At that point, Vicky and I just looked at one another and started to laugh at how exhausted we were.'*

### **Interrater Reliability**

One third of the interview transcripts (5 from the TD group, 5 from the ASD group) were coded by a second experimenter. This second experimenter was blind to participant diagnosis. The second experimenter's scores in each category of results were compared to the first experimenter's scores and the scores from the two experimenters were said to be in agreement if they were within 2 points of each other (i.e., if the first experimenter counted 23 'events' for a particular participant and the second experimenter counted 25 'events' then the two were said to be in agreement). This margin of error was allowed as any coding scheme such as this one is open to a certain degree of human error and bias. Using this criteria, the two experimenters agreed on 88.38% of occasions (*s.d.* = 7.33). When the raw scores for the total numbers of details

given by each participant were compared between the two raters using an intra-class correlation, a high degree of interrater reliability was found (Cronbach's  $\alpha = .98$ ).

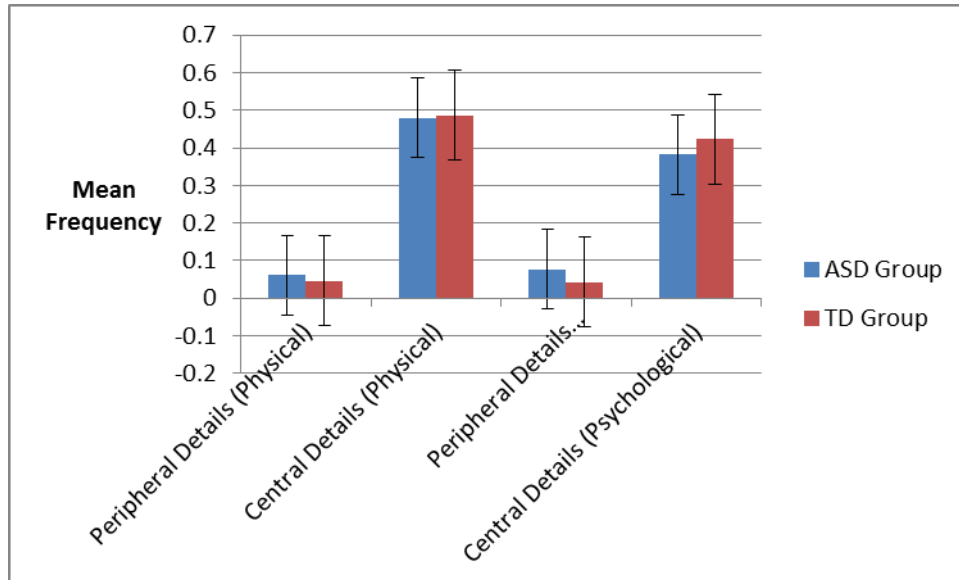
### **Questionnaire Measures**

Self-awareness was measured using the Private Self-consciousness Scale (PSC - Fenigstein, Scheier, & Buss, 1975). The PSC assesses individual differences in levels of private self-awareness with a focus on a person's awareness of their own internal thoughts and feelings. This scale has been used extensively to assess internal thoughts, feelings and attitudes (Anderson, Bohon et al. 1996) (Mittal & Balasubramanian 1987) and has a high test-retest validity (Fenigsteing, Scheier & Buss, 1975)..

### **Results: Experiment 5.1**

The raw data were recoded into proportions, so that the number of details in each category was expressed as a proportion of the total number of details recalled. This provided a measure of the level of detail which was independent of the length of utterance. A MANOVA was conducted on the data to explore the effect of Group (ASD and TD) on the proportions of central and peripheral details recalled for physical cue words and psychological cue words separately. The MANOVA therefore had four dependent variables, namely proportion of physical central details, proportion of physical peripheral details, proportion of psychological central details and proportion of psychological peripheral details. It was found that Group had a significant effect on the level of detail given for both proportion of peripheral psychological details,  $F(3,26) = 6.15, p = .02$ , and proportion of central psychological details,  $F(3,26) = 6.15, p = .02$ . The effect of Group on proportion of peripheral physical details,  $F(3,26) = 1.14, p = .30$ , and proportion of physical central details,  $F(3,26) = 1.14, p = .30$ , was non-significant. Using Pillai's Trace, the overall effect of Group approached significance,  $V = .19, F(3,26) = 3.06, p = .06$ . Figure 5.3 illustrates these findings.

Figure 5.3. Mean proportions of peripheral and central details given by the ASD and TD groups in response to physical and psychological cue words. Error bars represent 1 SEM.



This effect of Group was explored in more detail using a series of paired sample t-tests to assess category-by-category differences in the scores of the ASD and TD groups. As there were significant differences in the length of utterance (and therefore the number of details in all categories) between the two groups (Physical words:  $t(14) = -2.37, p = .03$ , Cohen's  $d = -.97$ ; Psychological words:  $t(14) = -2.74, p = .02$ , Cohen's  $d = -1.22$ ), the raw data were converted into proportions, so scores in each category were expressed as a percentage of the total number of central details generated by each participant.

For physical cue words, significant differences were found between the scores of the two groups in the Perceptual details, External details and Person categories. The differences in the first two categories mentioned are of particular interest; people with ASD appear to be giving around the same number of descriptive physical details as people without ASD, but, in the ASD group, these details have more of a removed, 'third person' feel (and, hence, are classified as 'external', rather than 'perceptual' details). By contrast, in the TD group, the majority of details given have an immediate 'first' person feel and are therefore classified as 'perceptual' rather than 'external'.

For psychological cue words significant differences were found in the Perceptual details, External details, Emotions, Person, Other Thoughts and Other Actions categories. The same pattern of results in the Perceptual and External details categories was found here as was found for physical cue words. In addition to this, the ASD group gave fewer details relating to emotions and the presence, actions and thoughts of others. However, for both physical and psychological cue words, they gave a similar level of detail in the more factual categories such as Time and Place references.

Paired sample t-tests were conducted to further explore the effects of Word Type and group separately. In order to explore the effects of Word Type on proportion of central details recalled, data from the TD and ASD groups was analysed separately. In the TD group, Word Type had a significant effect on level of detail recalled in the Perceptual details, Thoughts, Time, Place, Person, Other Thoughts, and Other Actions categories. Word Type did not have a significant effect on number of central details recalled in the External Details, Event and Emotions categories. Table 5.4 shows the t-test results for each category.



**Table 5.2. Comparisons between physical and psychological cue words for the TD Group.**

<b>Category</b>	<b><i>t</i></b>	<b><i>p</i></b>	<b>Cohen's <i>d</i></b>
<b>Perceptual Details</b>	12.03	.001*	-3.80
<b>External Details</b>	0.18	.86	-0.22
<b>Thoughts</b>	9.36	.001*	-2.96
<b>Time</b>	3.63	.001*	-0.98
<b>Place</b>	4.45	.001*	-1.57
<b>Emotions</b>	1.64	.12	-0.88
<b>Person Present</b>	5.26	.001*	-1.96
<b>Event</b>	0.99	.34	-0.44
<b>Other Thoughts</b>	3.17	.01*	-0.29
<b>Other Actions</b>	3.01	.03*	-1.11

\*- *Test is significant at the .05 level.*

In the ASD group, Word Type appeared to have a smaller effect on number of details recalled overall (i.e. it had a significant effect on fewer categories of detail). However, Word Type did have a significant effect on the level of detail recalled in the Perceptual details, Thoughts, Time, and Person, categories. Within the ASD group, Word Type did not have a significant effect on the proportion of central details recalled in the External details Emotions, Place Event, Other Thoughts, and Other Actions, categories.

Interestingly, the means for the physical words are higher than the means for the psychological words in each of these categories except, perhaps unsurprisingly, Thoughts and Person present. This implies that, in general, the group with ASD recalled a greater number of physical details

than psychological details across most categories. This idea will be explored in more detail below Table 5.4 shows the t-test results for each category.

**Table 5.3. Comparisons between the physical and psychological cue words for the ASD group.**

<b>Category</b>	<b><i>t</i></b>	<b><i>p</i></b>	<b>Cohen's <i>d</i></b>
<b>Perceptual Details</b>	6.13	.001*	-2.06
<b>External Details</b>	0.79	.44	-0.25
<b>Thoughts</b>	7.14	.001*	-2.06
<b>Time</b>	4.34	.001*	-1.42
<b>Place</b>	1.41	0.18	-0.53
<b>Emotions</b>	0.98	-0.34	-0.23
<b>Person present</b>	3.04	.01*	-0.78
<b>Event</b>	1.02	.33	-0.12
<b>Other Thoughts</b>	1.89	.08	0.39
<b>Other Actions</b>	1.08	.30	-0.28

\*- Test is significant at the .05 level.

This was explored by using paired t-tests to compare directly the overall numbers of central and peripheral details generated for each type of cue word within each group. This is illustrated in figure 5.3. In the TD group, the number of peripheral details given did not differ significantly between physical and psychological cue words,  $t(14) = .41$ ,  $p = .69$ , Cohen's  $d = .09$ . However, there was a significant difference when numbers of central details were compared,  $t(14) = 3.58$ ,  $p = .003$  (Cohen's  $d = .53$ ), with the mean for physical cue words ( $M = 143.67$ ,  $SD = 44.8$ ) being greater than the mean for psychological cue words ( $M = 122.67$ ,  $SD = 37.26$ ). In the ASD group, there was a significant difference in the number of peripheral details recalled for physical and psychological cue words,  $t(14) = -2.07$ ,  $p = .05$ , Cohen's  $d = -.25$ , with the mean for psychological cue words ( $M = 15.40$ ,  $SD = 16.03$ ) being significantly higher than the mean for

physical cue words ( $M = 11.80$ ,  $SD = 14.93$ ). The difference in the number of central details recalled was near significant,  $t(14) = 1.95$ ,  $p = .07$ , Cohen's  $d = .41$  and the mean for physical cue words ( $M = 81.20$ ,  $SD = 60.44$ ) was higher than the mean for psychological cue words ( $M = 60.80$ ,  $SD = 37.37$ ). This suggests that the ASD group gave more peripheral and fewer central details in response to psychological cue words, implying a lack of specificity in the psychological memories generated.

To investigate this further, paired sample t-tests were conducted to compare the specificity of the physical and psychological memories generated within each group. In the TD group, there was no significant difference in specificity between the physical and psychological conditions,  $t(14) = .29$ ,  $p = .78$ , Cohen's  $d = 0.09$ . However, in the ASD group, there was a significant difference in specificity between the two conditions,  $t(14) = 2.48$ ,  $p = .03$ , Cohen's  $d = .70$ . The mean specificity for physical cue words ( $M = 27.40$ ,  $SD = 9.92$ ) was greater than the mean specificity for psychological cue words ( $M = 20.40$ ,  $SD = 10.18$ ). This suggests that the ASD group generated more specific memories in response to physical as opposed to psychological cue words.

### **Correlation analyses**

Correlations between performance on the two questionnaires (the Private Self-Consciousness Scale – PSC, and the Autism Quotient Scale – AQ) and numbers of physical and psychological details recalled were also assessed. When the ASD and TD groups were combined, several significant correlations were found. There was a significant correlation between performance on the AQ and numbers of physical central details,  $r = -.51$ ,  $p = .004$ , and the numbers of psychological central details,  $r = -.64$ ,  $p < .001$ . This is particularly interesting as it suggests that the level of ASD-like traits present had a strong influence on the level of detail recalled in both the physical and the psychological domain. There were no significant correlations between AQ scores and levels of peripheral details recalled in either the physical,  $r = -.27$ ,  $p = .15$ , or the psychological,  $r = -.17$ ,  $p = .38$ , domain.

Somewhat unexpectedly, there were no significant correlations between the PSC and level of recall in either domain (peripheral physical details:  $r = -.29, p = .12$ , physical central details:  $r = -.19, p = .31$ , peripheral psychological details:  $r = .004, p = .98$ , psychological central details:  $r = -.23, p = .22$ ).

The results from the AQ were examined in more detail by looking at the ASD and TD groups separately. In the TD group, there were no significant correlations between the AQ and the level of detail recalled in any domain (peripheral physical details:  $r = .02, p = .93$ , physical central details:  $r = .09, p = .75$ , psychological peripheral details:  $r = .21, p = .46$ , psychological central details:  $r = .19, p = .51$ ). In the ASD group, the results were rather different. There were significant correlations between the AQ and the levels of physical,  $r = -.52, p = .05$ , and psychological,  $r = -.54, p = .04$  peripheral details recalled. There were no significant correlations between the AQ and levels of physical,  $r = -.27, p = .33$ , or psychological,  $r = -.48, p = .07$ , central details recalled.

### **Discussion: Experiment 5.1**

The results were in line with our initial predictions; level of detail recalled was dependent upon Group (TD or ASD) and upon Word Type (psychological or physical). Broadly, participants in the ASD group reported greater numbers of details in response to physical as opposed to psychological cue words. They also generated fewer psychological details across both categories of word.

Before examining these results in detail, it is worth commenting on differences in surface features of the data between the two groups, most notably the fact that the group with ASD produced utterances which were significantly shorter than the group without ASD in response to all of the cue words. Although, they were able to retrieve approximately the same number of memories as the TD group, the ASD group appeared to find the task more difficult, often hesitating before responding or pausing a number of times while speaking. The ASD group also

tended to give less specific answers than the TD group. One participant commented at the start of the interview '*I'm not very good at memories*'. These findings are in line with Goddard et al (2007) and others who found that participants with ASD gave somewhat limited answers to memory questions. From the data at hand, it is difficult to tell whether participants with ASD found this task challenging because of an impairment in autobiographical memory or because of more general communication difficulties. In order to avoid this problem, future studies should also include a narrative control task (for an example, see Lind, Williams, Bowler & Peel, 2014) which could be used to assess general verbal fluency and communication ability. As their verbal IQ scores did not differ significantly from those of the TD group (and all were able to make general conversation with the experimenter) it seems likely that the task was perceived as difficult because of its focus on autobiographical memory rather than its focus on communication.

It was predicted that the strength of the self-concept and the level of ASD-like features present would influence memory performance and this was found to be the case. AQ scores were also correlated with the level of detail recalled in the ASD group and when both groups were combined. There were, however, a number of unexpected non-significant correlations, most notably, the lack of any significant correlations with scores on the PSC. It is likely that there were few significant correlations when the TD data was analysed in isolation due to a lack of variation in the sample, particularly where AQ scores were concerned. It would be interesting to repeat this task with a larger sample of TD participants or with participants selected for having either very low or very high (while remaining sub-clinical) AQ scores. It would be predicted that, under these circumstances, significant correlations of the kind found in the ASD group would start to appear. The data from the PSC is somewhat more difficult to explain, but it may be that it is tapping into a slightly different aspect of the self-concept to the AQ and the interview task or that it is a less sensitive measure of the same dimension. The lack of significant correlations may again have been influenced by the limited variability of PSC scores within the data set.

It was initially predicted that Word Type would influence the level of detail recalled. This was the case, but more so for the TD group than the ASD group. In the TD group, the level of details generated in nearly every category was influenced by the type of cue word given, while, amongst the ASD group, type of cue word only influenced level of detail in a very small number of categories. On reflection, these results do appear to be in line with our prediction that the TD group would generate far 'richer' and more detailed accounts of memories as most of the categories were more suited to one particular type of cue word (for example, the 'perceptual details' category was likely to be more relevant to physical rather than psychological descriptions). The lack of influence of word type on level of detail recalled across different categories in the ASD group may therefore be symptomatic of a lack of differentiation between physical and psychological memories.

In those categories where word type did have an effect on the level of detail recalled, participants in the ASD group always gave a greater amount of details in response to physical cue words. When total numbers of peripheral and central details were examined, it was found that, in the ASD group, the level of central details given was far higher for physical cue words than for psychological cue words. This trend was present, but reduced in the TD group. Another difference between the two groups was that the TD group gave equal numbers of peripheral details across the two word types, while the ASD group gave greater numbers of peripheral details in response to psychological cue words. This indicates that the differences in specificity between the two groups may have been driven by a lack of specificity by the ASD group in response to psychological cue words.

When responses to physical cue words were examined alone, it was found that the results of the ASD group were largely in line with those of the TD group. This links in to evidence from Lind and Bowler (2009), Williams and Happe (2009), and others that the physical self-concept is largely unimpaired in ASD. In contrast, when psychological cue words were considered, there were differences in level of detail in nearly every category, except for the very factual categories of 'time' and 'place'. These results suggest both that patterns of recall of psychological

experiences are somewhat usual in ASD and that memory itself is not impaired since details of specific times and places were recalled. This evidence for a paucity of detail in psychological recollections is similar to that found by Lee and Hobson (1998) and Farley, Lopez and Saunders (2010) who observed that, while participants did not always generate a reduced number of psychological statements, they generated psychological statements which were limited or 'generic' in tone and had something of a rote learned feel.

Another finding from previous research which is of note is that of Hurlburt, Happe and Frith (1994) who found that people with ASD were unimpaired when recalling the factual details of everyday experiences, but demonstrated a lack of introspection about them. Similarly, Millward, Powell, Messer and Jordan (2007) demonstrated that people with ASD showed no memory advantage for personally experienced events over observed events. This suggests that memory in ASD may have more of a factual, 'third person, quality than memory in those without ASD. In the current study, it was found that for both physical and psychological cue words, people with ASD gave significantly more external (factual) details than perceptual (experiential) details. This provides further evidence for autobiographical memory in ASD perhaps being less episodic and more semantic than autobiographical memory in those without ASD.

## **Chapter Six: Who Am I? Self Descriptive statements of Children with Autism Spectrum Disorder**

The experiments presented in this chapter were intended to build on the adult interview study (experiment 5.1) presented in the previous chapter. The state of the self-concept in ASD has been described previously along with evidence for the idea of an impaired psychological self-concept and an intact physical self-concept. In terms of the development of the self-concept in childhood, it is suggested that children with ASD experience stages one and two of Damon and Hart's four stage theory of self-concept development to the same degree as their mental age matched peers, but their experience of stages three and four may be somewhat truncated. The experiments presented so far would suggest that this is the case.

In the previous chapter, the relationship between autobiographical memory and ASD was discussed in some detail and, in particular, the evidence that there may be impairments of autobiographical memory in people with ASD. The results of experiment 5.1 suggest that these impairments of autobiographical memory are largely in the psychological domain in adults with ASD, with physical memories being recalled in the same level of detail as they were in the comparison group. In contrast, recall of more psychological details was at a lower level than was seen in the comparison group.

The current study aims to explore the nature of the self-concept in primary school children with a diagnosis of ASD aged between 7 and 10. We chose to work with children in this age group because it was felt that the comparison typically developing children would have a strong physical self-concept and a psychological self-concept which is present, but still developing. This would allow us to pick up on any potential



developmental delay in the psychological self-concept in the group with ASD. We wanted to use a mixed methodology with qualitative aspects here both so that our results could be compared with the results of the adult interview study and because we wanted to gain a fully fleshed out picture of how children with ASD see themselves. It was decided not to give the children a version of the interview task or Damon and Hart's self-understanding interview as it was felt that, both the children with ASD and the youngest of the typically developing children might find the prospect of having to speak for an extended period of time to an unfamiliar adult to be a daunting one.

Instead, a variation of Keller, Ford & Meachum's statement completion task (1977) was used in which children were asked to describe themselves by completing various self-referential statements designed to trigger either a physical or a psychological response. An interesting aspect of this task is that it does not rely on autobiographical memory and therefore allows the various facets of the self-concept to be examined in isolation from other cognitive constructs. This is something which has not been done extensively in past research.

Given the ages of the children, we would predict that the TD children would generate significant numbers of psychological statements and statements which were connected with the social self. We also predicted that the TD children would generate large numbers of physical statements with an emphasis on statements which were concerned with the self as an agent of action as, according to Damon and Hart's four stages of self-concept development, these children should be between stages two and three (the active self and the social self). Within the ASD group, we would predict that the pattern of physical statements generated (i.e. the presence of a high number of action statements) would be very similar to that found in the TD group. However, the ASD group were

likely to generate fewer and more limited psychological statements than the group without ASD. Experiment 6.1 was completed by TD children only. This was done in order to establish a large baseline with which to compare the ASD group. A group of children with ASD and a group of gender-, age- and IQ-matched comparison children took part in experiment 6.2.

## **Method: Experiment 6.1**

### **General**

All participants completed the experimental task (described below). The task took approximately 10 minutes to complete, although the time varied considerably between participants.

### **Participants**

Prior written informed consent was given by a parent or guardian of all participants in accordance with the University of Durham Research Ethics Committee. In addition to this, participants themselves gave verbal consent at the start of the testing session.

Participants consisted of 21 typically developing children between the ages of 8 and 10 years (8 male). This age range was selected as participants younger than 8 were likely to have a less developed psychological self-concept than older children (Damon, 1991).

All participants had no current or past diagnoses of developmental disorders.

Participants were recruited through local schools and through advertisements sent out to university staff and students. Participant characteristics are given in table 6.1.

**Table 6.1. Participant Characteristics.**

	<b>Minimum</b>	<b>Maximum</b>	<b><i>M</i></b>	<b><i>sd</i></b>
<b>Age</b>	8.0	10.0	9.19	0.87
<b>Verbal IQ</b>	84	145	113.86	19.89
<b>Performance IQ</b>	78	125	100.38	11.89
<b>Full Scale IQ</b>	84	138	108.00	17.18

## **Materials and Procedure**

### **Selection of stimuli and task design**

The experimental task used was a variation on the design used by Keller, Ford, and Meachum (1978). Participants were asked to describe themselves by completing a number of statements beginning with either 'I am...' or 'I can...'. The 'I am' statements were designed to elicit a predominantly psychological response (e.g. 'I am a nice person'), although physical responses could also be given (e.g. 'I am a girl'), while the 'I can' statements were designed to elicit a physical response (e.g. 'I can swim'). Again, answers here were not restricted to the physical – a number of children gave psychological responses, for example 'I can make friends easily'. The aim here was not to generate five physical statements and five psychological statements, but was instead to see how many physical and psychological responses the child generated spontaneously when given both physical and psychological prompts. The final part of the task required children to generate five unprompted statements; participants were asked if there was anything else they wanted to tell the experimenter about themselves and it was stressed that they could say anything at all and did not have to begin the statements with either 'I can' or 'I am'. Again, the aim here was to see how many physical and how many psychological responses were made.

The method used here is similar to that employed by Keller, Ford, and Meachum (1977), but with one key difference. The number of statements generated in each category was reduced from 10 to 5. This was done to make the task less taxing both for the youngest children in the typically developing group and for the children in the group with ASD whose language development may be impaired when compared to that of their typically developing peers.

### **Procedure**

Participants were presented with a worksheet on which the statement prompts were written (e.g. 'I am' and 'I can'). Five numbered blank spaces were left for the unprompted statements. The experimenter then told the child *'I'd like to write a description of you on this piece of paper.'*

*Can you help me by telling me how to finish these sentences?*’ The experimenter then wrote down the child’s responses, giving the prompts *‘What else are you?’* and *‘what else can you do?’* as necessary. For the final, unprompted section, the experimenter asked *‘What else can we say about you? It can be anything at all.’* If a child was unable to think of anything to say, the experimenter gave both a physical and a psychological example (e.g. *‘If we were writing about me, I might say ‘I am a girl’ or ‘I am messy’*). If the child was still unable to come up with a response, the experimenter moved on to the next section and then revisited the previous section once the child had had time to think. Despite this, a small minority of children were unable to think of the full 15 statements, but all thought of at least two statements in each section. More specifically, two children came up with only 14 statements, 1 came up with 13 statements and three children came up with 12 statements.

### **Scoring**

Statements were coded firstly as being either physical or psychological in nature. Statements were then coded into 10 categories based on those used by Keller, Ford and Meachum (1978). Five of these were physical and five were psychological.

The five physical categories considered were ‘actions’ (in which the self was seen as an agent – e.g. *‘I play football’*), body image (e.g. *‘I am pretty’*), statements regarding gender, age and personal characteristics (e.g. *‘I am tall’*). Body image statements were distinguished from statements about personal characteristics by treating the former as opinion and the latter as more factual; having blue eyes is a fact, while being pretty is more subjective. The five psychological categories considered were personality labels (e.g. *‘I am friendly’*), relationships with others (e.g. *‘Claudia is my best friend’*), possessions (e.g. *‘I have an iPhone’*), evaluations (e.g. *‘I am good at horse riding’*) and preferences (e.g. *‘The Lion, the Witch and the Wardrobe’ is my favourite book.* ).

Once the number of statements in each category had been counted, each number was expressed as a proportion of the total number of statements generated by each participant. Following

analysis of this data, the distribution of statements within the physical and psychological categories respectively was examined by expressing the number of statements in each category as a proportion of either the total number of physical or the total number of psychological statements generated by each child.

### Results: Experiment 6.1

As not all the participants generated the same number of statements, the raw data was used to calculate proportions, so the scores for each category of statement are reported as a proportion of the total number of statements – for example, a child who came up with 10 statements, of which 5 were related to physical actions, would have an ‘actions’ score of 0.5. A total physical proportion and a total psychological proportion were also calculated by adding together the numbers of statements generated in all of the physical categories (actions, body image, gender, age and personal characteristics) and all of the psychological categories (social relationships, possessions, personality, evaluations and preferences) respectively. Mean proportions for each category are shown below.

**Table 6.2. Mean proportions of statements in each category.**

<b>Category</b>	<b><i>M</i></b>	<b><i>sd</i></b>
Actions	.33	.09
Body Image	.03	.06
Gender	.01	.02
Age	.08	.09
Personal Characteristics	.05	.08
<b>Physical Total</b>	<b>.49</b>	<b>.16</b>
Social Relationships	.08	.10
Possessions	.02	.04
Personality	.13	.09
Evaluations	.13	.12
Preferences	.15	.13
<b>Psychological Total</b>	<b>.51</b>	<b>.16</b>

A repeated measures ANOVA with a within subjects factor of category type (physical and psychological) was conducted. There was no significant main effect of category type on the number of statements generated,  $F(1,20) = .06, p = .81, \eta^2 = .003$ . This reflects the fact that the participants made nearly equal numbers of physical and psychological statements. The effect of gender on the results was also examined. However, due to the low number of males in the sample and the resulting lack of variance within the male group, gender could not be included as a between subjects factor in the ANOVA. Instead, two t-tests were conducted to examine the effects of gender on each statements category separately. Gender had no effect on the number of statements generated in either the physical,  $t(19) = 0.71, p = .49$ , or the psychological,  $t(19) = 0.71, p = .49$ , categories. The raw data was then re-examined and the scores in each of the physical statement categories were transformed into proportions of the physical total score. The data from statements in each of the psychological statement categories underwent the same transformation. These new proportion scores are expressed below.

**Table 6.3: Proportions for Physical Categories**

<b>Category</b>	<b><i>M</i></b>	<b><i>sd</i></b>
<b>Actions</b>	.71	.19
<b>Body Image</b>	.05	.12
<b>Gender</b>	.02	.05
<b>Age</b>	.14	.14
<b>Personal Characteristics</b>	.08	.12

**Table 6.4: Proportions for Psychological Categories**

<b>Category</b>	<b><i>M</i></b>	<b><i>sd</i></b>
<b>Social Relationships</b>	.15	.20
<b>Possessions</b>	.04	.09
<b>Personality</b>	.25	.16
<b>Evaluations</b>	.24	.24
<b>Preferences</b>	.32	.30

A repeated measures ANOVA with a within-subjects factor of statement type was carried out on each of these new data sets. For the physical statements data, there was a significant main effect of statement type,  $F(4,80) = 81.39, p < .001, \eta^2 = .80$ . This reflects the fact that the mean proportion for the Actions category ( $.71, SD = .19$ ) was far higher than the mean proportion in any of the other categories. Of the other categories, Age statements ( $M = .14, SD = .14$ ) accounted for a large proportion of the remaining variance.

For the psychological statements, there was also a significant main effect of statement type,  $F(1,15) = 4.44, p = .003, \eta^2 = .18$ . However, the effect size here is noticeably smaller than for the physical statements. This is reflected in the proportion scores, with variance here being split fairly evenly between the personality ( $M = .25, SD = .16$ ), evaluations ( $M = .24, SD = .24$ ) and preferences ( $M = .32, SD = .30$ ) categories. The number of statements generated in the social relationships category was somewhat smaller ( $M = .15, SD = .20$ ) and the number of statements generated in the possessions category was smaller still ( $M = .04, SD = .09$ ).

### **Discussion: Experiment 6.1**

The key finding here is that participants made almost equal numbers of physical and psychological statements. Also of importance is the fact that age had no effect on the number of physical or psychological statements generated. This implies that, by the age of 8 (the youngest children in the sample), both the physical and psychological self-concepts are relatively well-developed. These children had moved past the stage of seeing themselves as purely physical beings and towards the stage of having a complicated, adult self-concept in which the self is viewed as one piece in a wider social, moral and political world.

Damon (1991) viewed the development of the self-concept as having four stages; stage one is a sense of self rooted entirely in the physical, stage 2 sees the self as an agent of action, stage 3 is concerned with the self as a social being and stage 4 incorporates moral, religious and ethical beliefs. The participants here seemed to be between stages 2 and 3. The vast majority of their physical statements (.71) were concerned with the self as an agent of action. This indicates that these children had moved beyond stage 1 and were currently still experiencing the tail-end of stage 2. Their psychological statements were more varied, but a large number (.15) concerned social relationships. A large proportion of statements (.24) involved evaluations of their own performance in various domains. In the vast majority of cases, this was related to the performance of others (for example, *'I can run faster than Gabrielle'*) which has a social dimension. This again indicates that participants were entering stage 3. None of the participants made any statements pertaining to moral, political, ethical or religious beliefs, implying that none had reached stage 4.

A quarter of the psychological statements generated (.25) consisted of statements about the participants' own personality (such as *'I am a happy person'*). By contrast, relatively low proportions of statements (.05 and .08 respectively) were concerned with body image or personal characteristics. This again implies that children, by this age, are defining themselves more in terms of personality than in terms of physical appearance.

### **Method: Experiment 6.2**

Participants in experiment 6.2 consisted of 11 children with a current diagnosis of ASD aged between 7 and 10 (1 female, 10 male) and 11 typically developing children (4 female, 7 male) matched as closely as possible to the group with ASD in terms of



gender, age and IQ (see table 6.5 for participant characteristics). Participants in the TD group had no current or past diagnosis of any developmental disorders and all scored below the clinical cut-off for ASD on the SRS-2 (Constantino et al, 1012). Participants were recruited through local schools and through email advertisements sent out to university students and staff.

All participants in the group with ASD had received a formal diagnosis of autism spectrum disorder or Asperger's Syndrome (2 participants). All diagnostic information was checked rigorously. All participants also scored above the cut-off for clinical ASD on the SRS-2. Differences in age and IQ between the ASD and TD groups were non-significant (see table 6.5 for group comparisons).

**Table 6.5: Participant Characteristics and Group Comparisons.**

	ASD Group		TD Group		Group Comparisons		
	<i>M</i>	<i>sd</i>	<i>M</i>	<i>sd</i>	<i>t</i>	<i>p</i>	Cohen's <i>d</i>
<b>Age</b>	9.00	0.77	9.09	0.54	0.36	0.72	0.01
<b>VIQ</b>	112.64	14.99	105.27	34.90	0.73	0.48	0.27
<b>PIQ</b>	107.82	17.43	102.82	16.28	0.67	0.52	0.30
<b>FSIQ</b>	111.09	16.15	109.00	16.27	0.28	0.79	0.61

## Results: Experiment 6.2

The data from experiment 6.2 were analysed in the same way as the data from experiment 6.1. The raw data was used to calculate proportions of the total number of statements for each category. The majority of children in both groups generated 15 statements, but 5 children in the ASD group and 4 children in the TD group came up with smaller numbers of statements (in the ASD group, 1 generated 14 statements, 3 generated 12 statements and 1 generated 11 statements. In the TD group, 2 children

generated 14 statements and 2 generated 12 statements). The proportions of statements which could be classed as psychological or physical were also calculated. The means and standard deviations of these proportions for the TD and ASD groups are shown in the table below.

**Table 6.6: Means and Standard Deviations of proportions for the ASD and TD groups.**

<b>Category</b>	<b>TD Group</b>		<b>ASD Group</b>	
	<i>M</i>	<i>sd</i>	<i>M</i>	<i>sd</i>
Actions	.26	.16	.34	.28
Body Image	.02	.04	.03	.06
Gender	.02	.05	.01	.03
Statements				
Age	.09	.09	.15	.16
Statements				
Personal	.10	.11	.14	.15
Characteristics				
<b>Physical total</b>	<b>.50</b>	<b>.17</b>	<b>.65</b>	<b>.19</b>
Relationships	.04	.07	.01	.03
Possessions	.02	.06	.06	.09
Personality	.17	.15	.02	.04
Evaluations	.16	.19	.08	.09
Preferences	.11	.13	.17	.13
<b>Psychological</b>	<b>.50</b>	<b>.17</b>	<b>.34</b>	<b>.18</b>
<b>Total</b>				

A repeated measures ANOVA with a within subjects factor of Statement Type and a between subjects factor of Group was then conducted on the data for physical and

psychological totals. This revealed a non-significant effect of Statement Type,  $F(1,20) = 4.02, p = .06, \eta^2 = .17$ . The main effect of Group was also non-significant,  $F(1,20) = 1.00, p = .33, \eta^2 = .05$ . However, the interaction between Statement Type and Group was significant,  $F(1,20) = 4.43, p = .05, \eta^2 = .18$ .

The effect of Gender on numbers of statements generated was also examined. Again, gender could not be included in the ANOVA, due to the inclusion of a low number of females. Two t-tests were instead conducted in order to explore the effects of Gender on physical and psychological totals separately. It was found that Gender had no effect on the number of statements generated in either the physical,  $t(19) = 0.52, p = .61$ , or the psychological,  $t(19) = 0.52, p = .61$ , categories.

In order to explore this effect further, a series of t-tests was carried out to examine the differences between total physical scores for the ASD and TD groups and total psychological scores for the ASD and TD groups. There was a significant difference between the two groups in terms of the number of physical statements made,  $t(10) = 2.23, p = .05$ , Cohen's  $d = -0.83$ . This is due to the fact that the mean physical total score for the ASD group ( $.65, SD = .19$ ) was higher than the mean physical total score for the TD group ( $.5, SD = .17$ ). There was also a significant difference between the two groups in terms of the number of psychological statements made,  $t(10) = 2.47, p = .03$ , Cohen's  $d = .89$ . This reflects the fact that the mean number of psychological statements made was lower in the ASD group than in the TD group. In other words, the group with ASD made significantly fewer psychological statements and more physical statements than the group without ASD.

In order to explore the responses of the two groups in each of the categories of statement more fully, the raw data were re-analysed to generate scores which were

proportions of either the physical or psychological total score (depending on whether the category in question was physical or psychological). These new proportion scores are shown in the tables below and in figures 6.1 and 6.2.

**Table 6.7: New Proportion Scores for Physical Categories**

Category	ASD Group		TD Group		Group Comparisons		
	<i>M</i>	<i>sd</i>	<i>M</i>	<i>sd</i>	<i>t</i>	<i>sd</i>	Cohen's <i>d</i>
<b>Actions</b>	.49	.41	.52	.24	0.21	0.84	- 0.09
<b>Body Image</b>	.04	.10	.04	.10	0.03	0.98	0.00
<b>Gender</b>	.01	.04	.04	.10	0.97	0.36	- 0.39
<b>Age</b>	.25	.29	.21	.23	0.40	0.70	0.15
<b>Personal</b>	.23	.23	.19	.21	0.55	0.59	0.18
<b>Characteristics</b>							

**Table 6.8: New Proportion Scores for Psychological Categories**

Category	ASD Group		TD Group		Group Comparisons		
	<i>M</i>	<i>sd</i>	<i>M</i>	<i>sd</i>	<i>t</i>	<i>sd</i>	Cohen's <i>d</i>
<b>Relationships</b>	.03	.11	.09	.16	1.04	.33	-0.44
<b>Possessions</b>	.17	.25	.03	.10	1.96	.08	0.74
<b>Personality</b>	.07	.15	.39	.36	2.98	.02*	-1.16
<b>Evaluations</b>	.24	.24	.32	.42	0.34	.74	-0.23
<b>Preferences</b>	.49	.22	.17	.21	2.9	.02*	1.43

*\*Test is significant at the .05 level.*

Figure 6.1. Mean proportions for physical categories. Error bars represent standard error (1 SEM).

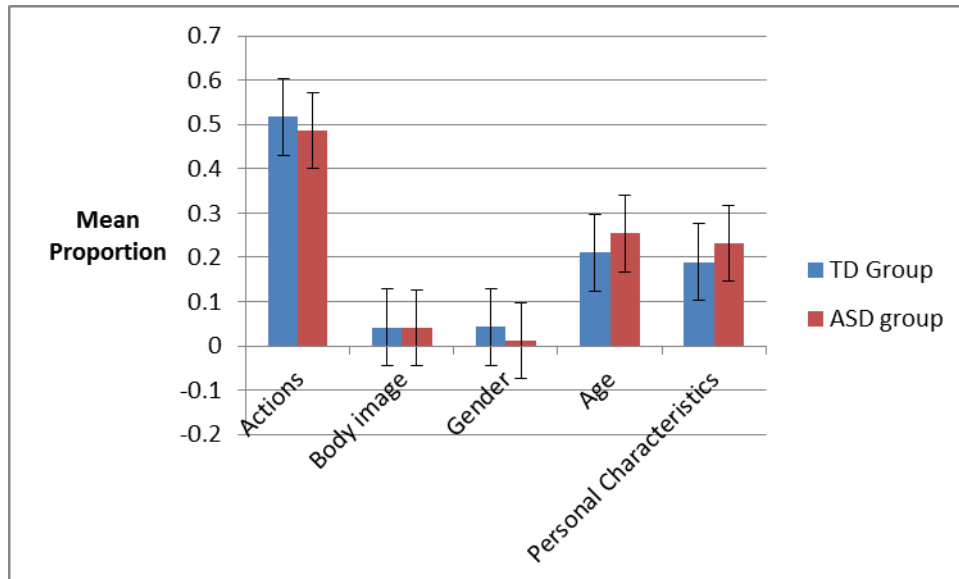
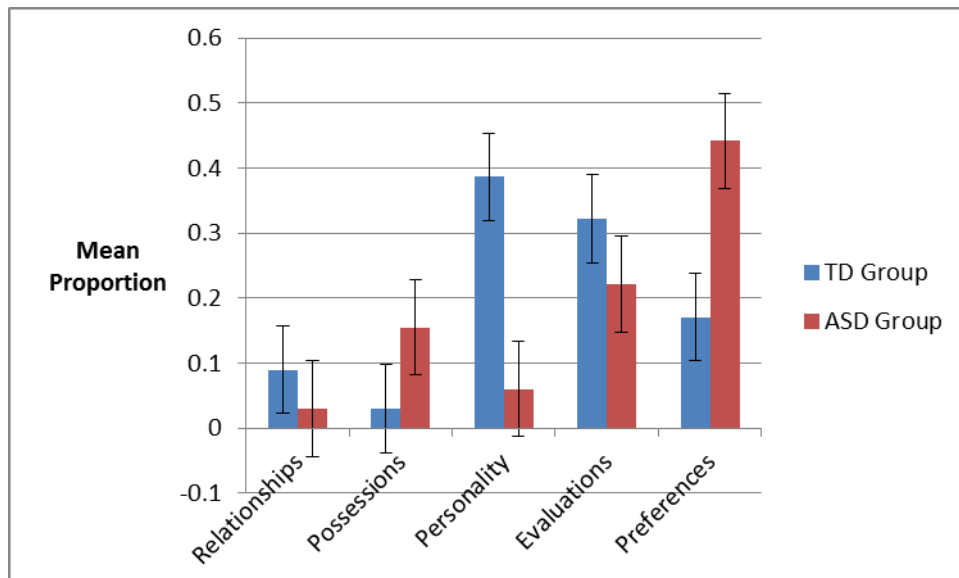


Figure 6.2. Mean Proportions for psychological categories. Error bars represent standard error (1 SEM).



A series of t-tests was then conducted to examine the differences in proportions between the two groups for each category. For the physical categories, no significant differences were found between proportion scores for the two groups. For both groups, the greatest

number of statements fell into the Actions category and large numbers of statements also fell into the Age and Personal Characteristics categories.

For the psychological categories, no significant differences were found between the two groups for the proportions of statements in the Relationships, Possessions, and Evaluations categories. However, a significant difference was found in the Personality category. This reflects the fact that mean proportion of statements in the personality category was far higher in the TD group than in the ASD group. There was also a significant difference in the Preferences category. This reflects the fact that the mean proportion of statements in this category was higher in the ASD group than in the TD group. Therefore the ASD and TD groups showed a markedly different pattern of responses within the psychological categories; the majority of psychological statements made by the TD group were related to personality, while the majority of psychological statements made by the ASD group were related to personal preferences.

### **Discussion: Experiment 6.2**

The results of the TD group were in line with the results of experiment 6.1. Again, participants made nearly equal numbers of physical and psychological statements and, again, the largest proportion of physical statements were in the 'actions' category while proportions of psychological statements were more evenly distributed.

The results of the ASD group, however, were somewhat different. As initially predicted, the ASD group made a far greater number of physical statements than psychological statements. This is the pattern of results which we might expect to see in younger TD children and it seems to suggest that the children with ASD still had a self-concept which was predominantly physical. Interestingly, just like the TD children, the children

with ASD produced more physical statements describing actions than physical statements which could be placed into any other category. These kinds of action statements are indicative of the fact that, just like the TD children, the group with ASD had moved into the second stage (and final physical stage) of Damon and Hart's model of self-concept formation. In other words, their physical self-concepts appeared to be just as developed as those of their typically developing peers. Further evidence for this idea comes from the fact that the children with ASD showed exactly the same pattern of responses in the physical domain as the children without ASD; the greatest proportion of their statements fell into the actions category, with large proportions of statements also being classed as describing age and personal characteristics and much smaller proportions of statements being concerned with body image and gender.

In the psychological domain, results were somewhat different. Both the TD and ASD groups made small numbers of statements related to relationships and larger numbers of statements related to evaluations and possessions, but this is where the similarities end. Importantly, the TD group made a very large number of statements related to their own personalities (e.g. *'I am a kind person'*) while the ASD group made almost none. The ASD group instead made large numbers of statements which expressed personal preferences (e.g. *'The Lion, the Witch and the Wardrobe' is my favourite book'*) while the TD group made less of these statements.

The number of statements in the personality category is perhaps the most direct measure of the psychological self-concept. The TD group demonstrated a pre-occupation with their own personalities which appears to be indicative of a deeply ingrained psychological self-concept. Their statements in this category also seemed spontaneous and were not always complimentary (one boy commented *'I can be really mean to*

*people* '). The statements of the ASD group were not only fewer in number, but also seemed to have more of a stereotyped quality; several stated '*I am a good boy*' or '*I am nice*'. Although impossible to prove, some of these statements appeared to be repetitions of things other people had said to them. Indeed, evidence from Hill, Berthoz and Frith (2005) suggests that people with ASD may learn to describe their own personality traits by rote.

The greatest proportions of psychological responses from the ASD group were in the preferences and possessions categories. This is perhaps unsurprising as these are the facets of the psychological self-concept which are usually seen as emerging earliest in developmental time – in particular, children have some sense of ownership over possessions by the age of two as evidenced by sibling disputes over toys (Ross, 1996). Therefore, these are the aspects of the psychological self-concept which may emerge concurrently with the physical self and so be somewhat less impaired in ASD. The high numbers of statements in the preferences category may also be linked to the obsessive interests which often characterise ASD (WHO, 2003). Having said this, when the raw data is considered, rather than proportions, children with ASD still made fewer statements related to preferences and possessions than the children in the TD group.

Perhaps the most surprising result is that the group with ASD and the group without made the same proportion of statements relating to relationships with others. However, this can perhaps be explained partly by the fact that the TD group made surprisingly few statements about relationships (far fewer than the TD children who took part in experiment 6.1). And again, when the raw data is considered, the group with ASD made far less statements about social relationships with peers and far more statements about



family relationships (although these differences were too small to analyse statistically) than the group without ASD.

### **General Discussion**

The aim of experiment 6.1 was twofold; firstly to provide a large baseline for the ASD group in experiment 6.2, and, secondly, to investigate the state of the self-concept in typically developing children during middle childhood. Very few studies to date have attempted to directly investigate different elements of the self-concept in children of this age. However, our results are in line with those of the studies which do exist. In particular, our results conform to the framework laid out by Damon and Hart (1991) who suggested that the development of the self-concept goes through four stages. Damon and Hart's framework suggests that children move from stage 2 to stage 3 at around the age of 7 years and remain in stage 3 until at least the age of 10. This is in line with what we found. The children in experiment 1 came up with a large proportion of action related statements (which would be expected at stage 2), but they also generated a large number of stage 3 psychological statements, in particular, there was a predominance of social statements. As expected, none of the children made any reference to religion, ethics, politics or morality of the kind which might be seen at stage 4. In other words, their answers demonstrated the presence of a highly developed physical self-concept and a strong, but still developing, psychological self-concept. The control group in experiment 6.2 showed the same pattern of results, suggesting that the statement completion task is a reliable measure.

The group with ASD generated a higher number of physical statements than psychological statements, but, when physical statements were analysed alone, they showed the same pattern of results as the TD group, with a predominance of action-

related statements. This suggests that, like the TD group, they have reached, and fully experienced Damon and Hart's second stage of self-concept development. This finding is in line with the myriad of studies which suggest that children with ASD have a very well developed physical sense of self and a strong idea of themselves as an agent of physical action – for example, children with ASD are often skilled at mirror recognition (Ferrari & Matthews, 1983), display temporal self-awareness (Lind & Bowler, 2009) and can discriminate between self and other caused changes in their environment (Williams & Happe, 2009).

As expected, the ASD group generated significantly fewer psychological statements than the TD group. This would indicate a reduced psychological sense of self. This notion is reinforced by the fact that the group with ASD generated very few statements related to personality (while the TD group generated more statements in this category than any other), arguably the most direct measure of the psychological self-concept. Instead, many of the psychological statements which the group with ASD did generate were concerned with possessions and preferences. The predominance of preference statements may be linked to the obsessional interests that characterise ASD (WHO, 2003). The number of statements relating to possessions is also interesting as ownership is perhaps the earliest facet of the psychological self-concept to develop and it emerges well before the onset of Damon's third stage at 7 years (Ross, 1996). If, as has been suggested, the self-concept is impaired in ASD during the shift from physical to psychological self-awareness at the age of 7, then ideas of ownership should indeed be unimpaired since this construct emerges while the self-concept is still almost exclusively physical. In the next chapter ownership in ASD will be considered directly to ascertain whether or not this is the case.

Statements regarding possessions aside, the relative lack of psychological statements falls into line with ideas about the potential impairment of the psychological self-concept in ASD. In particular, it seems in keeping with the various autobiographical memory studies which have reported sparse recollection of detail and context in ASD (Hurlbert, Happe & Frith, 1994). These results are also similar to those of Lee and Hobson (2004) and Farley, Lopez and Saunders (2010) who found that adults with autism produced largely stereotyped responses to the more psychological questions on Damon and Hart's self-understanding interview.

In conclusion then, the results of experiment 6.1 provide support for Damon's four stage model of the development of the self-concept by showing that children aged between 8 and 10 have a sophisticated physical self-concept and a strong, developing psychological self-concept. The results from the group with ASD suggest that children with ASD have a physical self-concept which is in line with that of their TD peers, while their psychological self-concept is present, but less fully developed.

The results presented in this thesis so far seem to suggest that there is a slight impairment in the physical self-concept in ASD and a far greater impairment in the psychological self-concept along with potentially delayed development of the psychological self-concept. However, one of the primary aims of this thesis (as laid out in the general introduction) was to investigate whether the self-concept is an umbrella term for a number of distinct and separable cognitive constructs or whether the self-concept is one cognitive construct which grows and changes over time (i.e. around the age of seven, it evolves from something largely physical to something which is partly psychological). The results so far would imply that perhaps the physical and psychological self-concepts are separate constructs, since they manifest very differently

in ASD. However, this difference could also be due to truncated development of the self-concept as a whole, meaning that full development of the psychological self-concept never occurs in those with ASD. One way of ascertaining whether this is the case, or whether the psychological self-concept is something separate which is potentially impaired from birth in those with ASD, is to look at the one aspect of the psychological self-concept which emerges strongly before the age of 7, namely the ownership effect. If the self-concept is one cognitive construct which is not able to develop fully in ASD, then we would expect the ownership effect to be present in adults with ASD. If, however, the psychological self-concept is something separate which develops largely independently of the physical self-concept, then we would expect the ownership effect to be absent or reduced in adults with ASD. This idea is investigated in the next chapter.

## Chapter Seven: The Ownership Effect in Autism Spectrum Disorder

Previous chapters have established the idea of an impaired psychological self-concept in ASD and a physical self-concept which remains largely intact. However, this tells us very little about whether the physical and psychological self-concepts are two aspects of the same cognitive construct or whether they are separate cognitive entities. In order to investigate this idea, the current chapter focuses on an element of the psychological self-concept which is in place at a very early stage in development, namely the sense of ownership over objects. If the psychological and physical self-concepts are two aspects of the same thing which has a truncated development in ASD then it would be expected that the sense of ownership would be intact in those with ASD since the sense of ownership develops before the suggested foreshortening of the developmental trajectory. If, however, the psychological self-concept is something which is separate from the physical self-concept, then we would expect that its development would be impaired in ASD along with the development of the other aspects of the psychological self-concept.

It has been suggested that owned objects (i.e. objects that a person feels a personal investment in and which are deemed to be relevant to the self in some way) occupy a privileged cognitive processing status, being treated almost as extensions of the self (Beggan, 1992). Thus, the perceived value of owned objects is higher than that of non-owned objects (the “endowment effect”: Kahneman, Knetsch & Thaler, 1991), and owned objects are considered to have more positive characteristics than non-owned objects (the “mere ownership effect”: Belk, 1991).

Recent research has shown that sense of ownership also has pronounced effects on memory. For example, adult participants who were told that they owned certain items were significantly more likely to later recognise these items than those they had been told were owned by a confederate (Cunningham, Turk, MacDonald & MacRae, 2008). Moreover, this ownership effect is apparent in memory among young children as well as adults. For example, children aged between 4 and 6 years who had sorted pictures of everyday objects between “their” basket and a confederate’s basket were more likely to recognise self-owned than other-owned items (Cunningham, Vergunst, Macrae & Turk, 2012). Indeed, children as young as 2 years of age appear to have a sense of ownership over objects, as evidenced by heated disputes between siblings over toys (Ross, 1996). This implies that the sense of ownership is a relatively early developing psychological aspect of self that clearly affects memory and cognition.

The current pair of experiments build on the work of Cunningham, et al. (2008) and seek to ascertain whether the ownership effect is reliably present in typically developing adults (Experiment 7.1) and among intellectually high-functioning adults with ASD (Experiment 7.2). Participants in each study completed a recognition memory test (based on Cunningham et al.’s, 2008, study), that allowed the ownership effect to be quantified, (a questionnaire measure (the Private Self-Consciousness Scale; Fenigstein, Scheier, & Buss, 1975) to assess psychological self-awareness, and a quantitative measure of ASD traits (the Autism-spectrum Quotient; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001).

The main aim of Experiment 7.1 was to attempt to replicate the ownership effect previously observed in typically developing adults (Cunningham, Turk, MacDonald & MacRae, 2008). A secondary aim was to establish whether the ownership effect was

related to degree of psychological self-awareness and/or to sub-clinical levels of ASD traits. In Experiment 7.1, it was predicted that the ownership effect, as measured using a recognition memory task, would be present and that the strength of the effect would be positively correlated with degree of psychological self-awareness as measured by performance on the questionnaire, and negatively correlated with ASD traits.

Experiment 7.2 aimed to establish whether individuals with a clinical diagnosis of ASD show a typical ownership effect in memory and whether they show diminished psychological self-awareness as measured using the two questionnaires. This is the first time ownership effects have been explored or the PSC used in the study of ASD. Here, it was predicted that the strength of the ownership effect would be reduced or absent (due to impoverished psychological self-awareness) and the strength of the ownership effect would be positively correlated with degree of psychological self-awareness as measured by performance on the questionnaire, and negatively correlated with ASD traits.

### **Method: Experiment 7.1**

#### **Stimuli and Materials**

The stimuli comprised a set of 225 pictures of items commonly available to buy in a supermarket (see Appendix 3 for a complete list). These items were divided into three shorter lists of 75 items each. The lists were closely matched for mean word length and number of syllables. A MANOVA revealed that there was no significant difference in the number of syllables or the length of words across the three word lists  $F(4,428) = .28$ ,  $p = .89$ ,  $\eta_p^2 = 0.89$ . Each list rotated through three counterbalanced versions of the task, such that each list appeared as ‘self-owned’ target items in one version, ‘other-owned’ target items in one version, and lure items in one version. Participants were randomly assigned to one of the three versions of the task. Stimuli took the form of colour

photographs of the items printed onto 885mm x 185mm laminated cards with white backgrounds. During the study phase, self-owned and other-owned items were presented on cards with red and blue borders, respectively. During the test phase, self- and other-owned target pictures (as well as lure pictures) were presented on cards without coloured borders, ensuring that participants could not simply use border colour to determine whether items belonged to self or other. Participants were also given a red shopping basket into which their cards would be placed. The experimenter had an identical blue shopping basket.

## **Procedure**

### **Study Phase.**

In the study phase, participants were presented with 150 picture cards (from two of the three lists) stacked in a random order. Half of the pictures (i.e., pictures from one list) had a red border and half (i.e., pictures from the other list) had a blue border. Participants were also presented with a blue shopping basket and a red shopping basket. Participants were instructed to place cards with a red border into the red basket and cards with a blue border into the blue basket. Crucially, participants were told that they ‘owned’ the red basket and its (eventual) contents while the experimenter ‘owned’ the blue basket and its (eventual) contents. It was stressed to participants that, when sorting the cards, they should pay attention both to the colour of the border and to the item shown on the card. Cards were presented in a random order subject to the constraint that no more than four red or blue cards appeared in a row.

### **Test Phase.**



A standard unexpected (yes/no) recognition test was used in which the 150 items seen previously in the study phase were presented (but *without* coloured borders), along with 75 previously unseen lure items from the remaining list of items which had not been presented in the study phase. Participants were presented with each item individually and asked whether or not it had appeared in the study phase.

### **Questionnaire Measures**

Self-awareness was measured using the Private Self-consciousness Scale (PSC; Fenigstein et al., 1975). Participants also completed the Autism-spectrum Quotient (AQ; Baron-Cohen et al., 2001).

### **Participants**

Participants were university students, aged between 18 and 24. Forty participants (38 female) took part. None of the participants had any current or past diagnosis of psychiatric disorders, according to self-report. All participants gave their informed consent and received course credit in partial fulfilment of their undergraduate psychology degrees for taking part in the study. This study received ethical approval from Durham University Psychology Research Ethics Committee.

## **Results: Experiment 7.1**

### **Experimental task**

With respect to recognition performance on the experimental task, we calculated hit rate (proportion of items seen at test that were correctly recognised as target items from the study phase), false alarm rate (proportion of lure items that were incorrectly identified as target items from the study phase), and corrected hit rate (hit rate minus false alarm rate; this provides an overall picture of recognition memory performance). These measures were calculated separately for self- and other-owned items. Table 7.1 shows

the hit rate, false alarm rate, and corrected hit rate for self-owned and other-owned items.

**Table 7.1: Means and Standard Deviations For Hit Rates, False Alarm Rates and Corrected Hit Rates in Each Condition**

Measure	Condition	<i>M</i>	<i>sd</i>
<b>Hit rate</b>	<b>Self-owned</b>	.65	.15
	<b>Other-owned</b>	.45	.14
<b>False alarm rate</b>	N/A	.18	.11
<b>Corrected hit rate</b>	<b>Self-owned</b>	.46	.18
	<b>Other-owned</b>	.26	.13

A repeated-measures ANOVA was conducted using corrected hit rate as the dependent variable and Referent (self-owned/other-owned) as the within-subjects variable. This revealed a significant main effect of Referent,  $F(1,39) = 99.27, p < .001, \eta_p^2 = 0.72$ . This reflected the fact that the mean corrected hit rate for self-owned items was higher than the mean corrected hit rate for other-owned items. Thus, a clear effect of ownership was present, as predicted.

### **Categorical analysis of experimental task.**

In addition to analysing the ownership effect as a continuous variable in each participant group, we also analysed the data categorically. For the purposes of categorical analyses, participants were deemed to have shown an ownership effect if their corrected hit rate for self-owned items was greater than their corrected hit rate for other-owned items. Using this definition of the ownership effect, 38/40 participants (95%) displayed the

ownership effect. The two participants who did not demonstrate the ownership effect recalled equal numbers of self and other owned items. Table 7.2 gives a breakdown of this categorical analysis, detailing how many more items participants remembered in the self as opposed to the other referent condition.

**Table 7.2. Breakdown of categorical analysis.**

	Number of items recalled in the self referent compared to the other referent condition.							
	-1 - 10	0	+1-5	+6- 10	+11- 15	+16-20	+21-25	+25 or more
<b>No of participants</b>	0	2	4	5	2	5	10	12

### Questionnaire data and relation to experimental task

Participants' scores on the PSC and the AQ are shown in Table 7.2.

**Table 7.3. Mean Scores on the Private Self-consciousness Scale, and Autism-spectrum Quotient scale**

Questionnaire	<i>M</i>	<i>SD</i>	Range
<b>Private Self-consciousness Scale</b>	24.05	5.87	15 - 37
<b>AQ</b>	12.53	5.94	2 - 23

For the purpose of the correlational analyses, difference scores (corrected hit rates for self-referent items minus corrected hit rates for other referent items) were calculated and used as a measure of the size of the ownership effect. The mean difference score was .20 ( $sd = .13$ ).

There was no significant correlation between ownership (difference) scores and scores on the PSC,  $r = -.12$ ,  $p = .45$ . However, a significant negative correlation was found between difference scores and scores on the AQ,  $r = -.33$ ,  $p = .04$ . In other words, the higher the levels of ASD-like traits, the smaller the size of the ownership effect.

### **Discussion: Experiment 7.1**

The purpose of Experiment 7.1 was threefold; firstly to provide a replication of the effect observed by Cunningham et al. (2008) and to extend the effect into an adult population, secondly to examine the associations between the ownership effect and specific aspects of psychological self-awareness as measured by the questionnaires and, thirdly, to act as a baseline for Experiment 7.2. The repetition of this task with TD participants across the two experiments allows us to establish the reliability of this task at demonstrating the presence of the self-referencing effect in a typical population before using it to draw conclusions about the presence or absence of a self-referencing effect in a population with ASD.

As expected, the ownership effect was clearly present in this typically developing sample, with self-owned items being recognised significantly more reliably than other-owned items. This is in line with the results obtained by Cunningham, Turk, MacDonald and MacRae (2008). This could be seen as providing evidence supporting hypotheses such as that of Beggan (1991) who suggest that owned objects become a psychological extension of the self. It may even be that the ownership effect is stronger than other self-referencing biases within the psychological domain since a sense of ownership appears to emerge at an earlier point in developmental time than other aspects of the psychological self-concept and, therefore, may be more deeply ingrained within an individual's psyche (Fasig, 2000).

Data from the PSC was included here to ascertain whether the strength of the self-referencing effect displayed was related to difficulties expressing inner thoughts and feelings. However, performance on the PSC did not correlate with the difference score

and this therefore suggests that the PSC is not necessarily measuring an aspect of the self which is relevant for the ownership effect. In contrast, there was a highly significant negative correlation between scores on the AQ and ownership difference scores, supporting our earlier prediction that the ownership effect may be affected by the presence of autism-like traits. This potential link was investigated more fully in Experiment 7.2, where the task was used with a population of adults with a current diagnosis of ASD.

### **Method: Experiment 7.2**

#### **Participants**

Sixteen adults with ASD (3 female) and 16 typically developing comparison adults (4 female) took part in this experiment, after giving written, informed consent. Participants were recruited from an existing database of participants who had previously taken part in studies conducted by the Autism Research Team at Durham University, and who had agreed to be contacted about future research projects. All participants received financial compensation for their participation. Participants in the ASD group had all received formal diagnoses of ASD ( $n = 12$ ) or Asperger's Syndrome ( $n = 4$ ), according to conventional criteria (American Psychiatric Association, 2000; World Health Organization, 1992). Diagnostic information was checked thoroughly to ensure diagnoses were rigorous and current. In addition to these diagnoses, severity of current ASD features was assessed with the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000). This measure was used with participants in the ASD group only. Two participants declined to complete this assessment for personal reasons. Consistent with their formal diagnoses, all participants with ASD who consented to taking part in the ADOS scored above the ASD cut-off ( $\geq 7$  points) on this measure. The two participants who declined to complete the ADOS scored above the ASD cut-offs on the AQ.

The AQ was administered to both participants in the ASD group and comparison participants in order to ensure that comparison participants did not display ASD-like symptoms and traits. As expected, all comparison participants scored below the ASD cut-offs on the AQ (< 26 points). Additionally a small minority of participants with formally diagnosed ASD scored below the cut-offs for ASD on the AQ. However, this is likely to have been due to the problems of validity which are inherent in using self-report measures. These participants scored above the ASD cut-offs on the ADOS and are therefore retained in the ASD group.

Verbal and non-verbal ability of both groups was assessed using the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). This allowed the two groups to be matched as closely as possible for both verbal and non-verbal ability. The groups were also matched closely for chronological age. Importantly, all effect sizes associated with group differences in baseline characteristics of age and IQ were negligible. Participant characteristics are presented in Table 7.3. This study received ethical approval from Durham University ethics committee.

## Procedure

The procedure was identical to that employed in Experiment 7.1.

**Table 7.4. Participant Characteristics (Descriptive and Inferential Statistics for Group Differences)**

	ASD Group		TD Group		Group Comparisons		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i>	<i>p</i>	Cohen's <i>d</i>
<b>Age</b>	31.33	9.91	35.31	14.70	0.96	.35	-0.32
<b>VIQ</b>	110.19	13.99	113.06	13.78	0.55	.59	-0.21
<b>PIQ</b>	112.53	14.21	116.69	10.86	0.68	.51	-0.33
<b>FSIQ</b>	112.31	14.49	116.63	12.44	0.81	.43	-0.32
<b>AQ*</b>	34.63	9.90	14.56	5.60	6.32	.001	2.50

\*The range of AQ scores for the group with ASD was 14 – 46 and the range of AQ scores for the TD group was 5 – 24.

## Results: Experiment 7.2

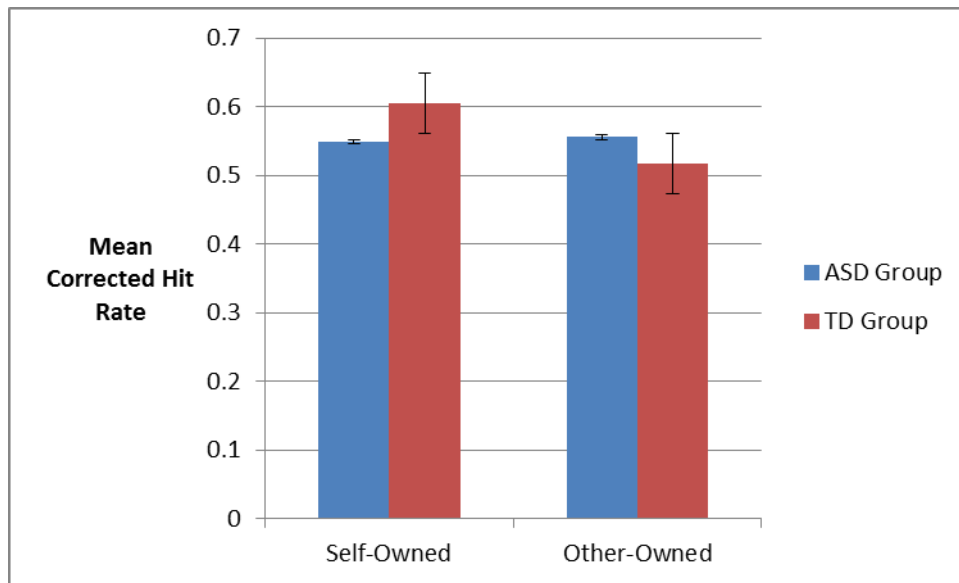
### Experimental task.

As in Experiment 1, hit rate, false alarm rate, and corrected hit rate were calculated for both self-owned and other-owned items. Table 7.4 and figure 7.1 show these rates among ASD and comparison participants.

**Table 7.5 Means and Standard Deviations for Hit Rates, False Alarm Rates and Corrected Hit Rates for Each Group in Each Condition**

Measure	Condition	ASD Group		TD Group	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Hit rate	Self-owned	.66	.17	.73	.12
	Other-owned	.67	.14	.65	.12
False alarm rate	N/A	.11	.07	.13	.05
Corrected hit rate	Self-owned	.55	.18	.61	.12
	Other-owned	.56	.16	.52	.11

Figure 7.1. Mean Corrected hit rates for self and other owned items in the ASD and TD Groups. Error bars represent 1 SEM.



A mixed-design ANOVA was conducted using corrected hit rate as the dependent variable, Referent (self-owned/other-owned) as the within-subjects variable, and Group (ASD/comparison) as the between-subjects variable. This ANOVA revealed a significant main effect of Referent,  $F(1,30) = 14.99, p = .001, \eta_p^2 = 0.33$ , reflecting superior recognition of self-owned items than other-owned items overall. The main effect of Group was not significant,  $F(1,30) = 0.03, p = .86, \eta_p^2 = .001$ . This suggests that there was no difference in general memory performance between the two groups. However, the interaction between Referent and Group was significant  $F(1,30) = 18.80, p < .001, \eta_p^2 = 0.39$ .

A series of within-participant and between-participant *t*-tests was conducted to break down this interaction. Among comparison participants, self-owned items were recognised significantly more reliably than were other-owned items,  $t(15) = 8.68, p < .001$ , Cohen's  $d = 0.78$ . Thus, comparison participants showed the expected ownership effect. However, among ASD participants, the difference between corrected hit rates for self-owned and other-owned items was non-significant,  $t(15) = 0.26, p = .80$ ,



Cohen's  $d = 0.06$ , reflecting the absence of an ownership effect in this group. An additional analysis revealed no significant difference in false alarm rates between the ASD and TD groups,  $t(30) = .82, p = .42$ .

### **Categorical analysis of experimental task.**

As in experiment 7.1, a categorical analysis was carried out on the data and, as before, participants were deemed to have shown the ownership effect if their hit rate for self owned objects was greater than their hit rate for other owned objects. All comparison participants (16/16, 100%), but only 7/16 (44%) of ASD participants, showed an ownership effect. This difference was statistically significant and associated with a large effect size,  $\chi^2 = 12.52, p < .001, \Phi = .63$ . Table 7.5 gives a breakdown of the categorical analysis.

**Table 7.6. Breakdown of categorical analysis.**

	Number of items recalled in the self referent condition compared to the other referent condition					
	-10 - 5	-4 - 1	0	+1 - 5	+6 - 10	+11 - 15
No of participants (ASD group)	3	6	0	5	1	1
No of participants (TD group)	0	0	0	5	9	2

### **Questionnaire data: Group differences and relation to experimental task**

Participant's AQ scores are presented in Table 7.3. In terms of score on the PSC, participants with ASD scored a mean of 22.18 ( $SD = 4.23$ ; range = 15-30), whereas comparison participants scored a mean of 19.25 ( $SD = 5.59$ ; range = 10-28). The difference between the groups in PSC score was significant,  $t = 2.3, p = .04, d = .59$ .

Ownership (difference) scores were also calculated by subtracting proportions of other owned items from proportions of self owned items. The mean difference score for the TD group was .09 ( $sd = .04$ ) and the mean difference score for the ASD group was -.01

( $sd = .08$ ). The difference between the scores in the two groups was significant,  $t(15) = 3.82, p = .002$ , Cohen's  $d = -1.58$ .

In the ASD group, there were no significant correlations between scores on the AQ and the PSC,  $r = -.09, p = .73$ . In addition, no significant correlations were found between ownership (difference) scores and scores on the PSC,  $r = -.48, p = .06$ . The correlation between scores on the AQ and the ownership (difference) score was also non-significant,  $r = .11, p = .69$ .

In the comparison group, there were no significant correlations between scores on the AQ and the PSC,  $r = .39, p = .13$ . There were also no significant correlations between ownership (difference) scores and scores on the PSC,  $r = .48, p = .06$ , or the AQ,  $r = -.12, p = .66$ .

As correlations were found between scores on the AQ and ownership (difference) scores in Experiment 7.1, a further correlation analysis was run in which the ASD and comparison groups were combined to add power to the test and correlations with the AQ were analysed. Using this combined sample, there was a significant negative correlation between scores on the AQ and difference scores,  $r = -.46, p = .01$ . Combining the groups in this way made no difference to the correlations (or lack of correlations) between other measures.

### **Discussion: Experiment 7.2**

Experiment 7.2 examined whether the ownership effect seen in experiment 7.1 was also present in a group of adults with high-functioning autism. As a sense of ownership over objects is a key component of the psychological self-concept (Beggan, 1992) which is

claimed to be impaired in ASD (Hurlbert, Happé, & Frith, 1994), it was hypothesised that this aspect of the self-referencing effect would be absent or diminished in the group with ASD.

Our results were in line with this hypothesis. The comparison group displayed a strong self-referencing effect, with self-referent items being consistently more accurately recalled than other-referent items. This effect was not present in the ASD group. This provides further evidence that people with ASD have an impaired or unusual psychological self-concept, since they do not display the psychological sense of ownership over objects which was displayed by the typically developing group.

The absence of the self-referencing effect was explored further by individually comparing the results of the self-referent and other-referent conditions across the two groups. There was no significant difference in recall for other referent items between the ASD and comparison groups, but there was a significant difference in recall for self-referent items between the two groups. The absence of a difference in the other-referent results rules out any suggestion that the group with ASD are simply less good at recalling the objects generally and points instead to a specific impairment of self-referencing. This provides further support for the idea that this result is driven by an impairment in the psychological sense of self, rather than a more general memory impairment.

The questionnaire measures were again included to ascertain whether there was a single factor underlying performance on the PSC and AQ which might be related to the strength of the self-referencing effect. However, no significant correlations were found between these measures in either group suggesting, as in experiment 7.1, that they are

measuring different constructs. Additionally, as in experiment 7.1, scores on the PSC did not correlate with the strength of the self-referencing effect in either group. While the sample size in this study was relatively small and the range of scores generated relatively narrow, the replication of this finding from experiment 7.1 suggests that these measures are not relevant to the ownership effect.

Interestingly, the correlation between AQ and the ownership (difference) score was marginally significant for the ASD group and reached significance once data from the ASD and comparison groups had been combined. Since the AQ is a commonly used measure of levels of autism-like traits, this would imply that the severity of autism present may have an effect on the strength of the self-referencing effect displayed. As the self-referencing effect is indicative of the presence of an unimpaired psychological self-concept, it may be that the level of autism-like traits present directly influences the strength of the psychological self-concept. This effect is further discussed below.

### **General Discussion**

Experiment 7.1 explored the relationship between the psychological self-concept and the ownership effect in a population of typically developing adults while Experiment 7.2 extended this to examine the nature of the self-referencing bias in the domain of ownership in a population of adults with ASD.

In both Experiments 7.1 and 7.2 the comparison participants showed a robust ownership effect. The effect found was large and consistent, implying that the self-referencing effect is reliable and resilient in this area. Effect sizes in Experiment 7.1 were similar to those found amongst the comparison participants in Experiment 7.2, thus allowing Experiment 7.2 to act as a small scale replication of the results of Experiment 7.1. This is important as one potential limitation of the study is the gender imbalance between

Experiment 7.1 and Experiment 7.2, with Experiment 7.1 using mostly female participants and Experiment 7.2 using mostly male participants. This imbalance is somewhat negated, however, by the similar effect sizes seen in the two experiments despite the very different gender balances and therefore suggests that gender is not a relevant factor.

The robustness of the ownership effect seen supports the view that a sense of ownership is an integral part of the psychological self-concept (Fasig, 2000). The pattern of self-referencing seen here is typical of the self-referencing pattern seen in studies that directly test other aspects of the self-concept, for example, by using visually or verbally presented linguistic descriptors (Engelkamp, 1982; Rogers, Kuiper & Kirker, 1977). Our findings are also relevant to the on-going debate about whether ownership can be considered to be a process dependent upon physical contact with the object in question or whether it is entirely psychological in nature. It has been suggested by Cunningham et al (2007), that physical contact has no influence on the strength of the ownership effect observed and the current findings support this view. While our participants did handle the self owned objects, importantly, they also handled the other owned objects, and yet, the ownership effect persisted.

The sense of ownership created here was transient and fairly artificial; participants knew that they would not be able to keep the items in their basket at the end of the study and the stimuli used were simply pictures of objects rather than the objects themselves. This marks a departure from many (although not all) previous studies in the area, in which participants were allowed to keep the owned objects (Beggan, 1992). Thus, ownership is a fairly abstract notion which is not necessarily linked to the presence of a physical object (as illustrated perhaps by the sense of ownership felt during online shopping

etc.). The concept of ownership as an abstract notion supports the idea that owned objects occupy a privileged cognitive processing status – they may be viewed as cognitive extensions of the self rather than objects per se.

In contrast to the robust ownership effect found in the comparison groups, the self-referencing effect was absent in the ASD group, with items from both the self-referent and other referent conditions being recalled equally well. However, overall numbers of items recalled did not differ between groups; the ASD group simply recalled near equal numbers of self and other referent words, rather than showing a preference for self referent words. This implies that the pattern of performance seen in the group with ASD was not due to a general impairment in memory, nor general inattention to the task or stimuli. This is in line with the results of other studies of the self-referencing effect in ASD – for example, Lombardo, Barnes, Wheelwright & Baron-Cohen (2007) found a similar pattern of results when memory for self and other referent trait adjectives was considered. The results support our initial predictions that aspects of the psychological self-concept are impaired in ASD (Williams & Happe, 2009; Lind & Bowler, 2009), while the physical self-concept remains relatively unimpaired (Amsterdam, 1972).

Having established that the ownership effect is robust in comparison participants in both studies and absent in the ASD group, we can consider the nature of the relationship between the ownership effect and the self. It had been hypothesised that the ownership effect depends on a sense of self that is deficient in ASD. However, while our results support this view, they also raise further issues. The strength of the ownership effect did not correlate with any aspect of performance on the PSC. This suggests that if the ownership effect is reliant on an aspect of self, it is not measured by this instrument. It

should also be taken into account that the PSC is a self-report measure and, as such, may suffer from respondents inaccurately reporting their own personality traits. This may have been a particular problem in the group with ASD as previous studies have suggested that people with ASD have a tendency to give answers to personality questions which appear to have been at least partly learned by rote (Lee & Hobson, 1998). However, this explanation cannot be extended to the TD groups studied. Moreover, the strength of the ownership effect correlated with scores on the AQ, a measure of ASD traits used in both clinical and subclinical populations and again based on self-report. Importantly, this effect was seen in TD participants (experiment 7.1) and approached significance in participants with ASD (experiment 7.2). This suggests that there is not a threshold of self-concept as measured by the AQ sufficient to produce an ownership effect, and below which the ownership effect is impaired. Instead, ASD traits as measured by the AQ over the complete range (TD and ASD) correlated with the strength of the ownership effect, even using the artificial and temporary ownership of pictures used in the current study. A further implication of these results, combined with the lack of correlation between the strength of the ownership effect and performance on the PSC, is that the self-referencing effect may be dependent upon a very specific aspect of the self and it may be this aspect which is impaired in ASD.

The absence of the ownership effect in the ASD group also has interesting ramifications for the study of the self-concept as a whole. At the beginning of this thesis, I set out to examine whether the self-concept was an umbrella term used to describe a number of different separable constructs (namely, the physical self and the psychological self) or whether the physical self and the psychological self were two aspects of the same thing. The evidence presented in previous chapters implies that the two are distinct constructs, but the evidence from this study is even more compelling. The sense of ownership over

objects is the earliest manifestation of the psychological self-concept. If the self-concept impairments seen in ASD were the result of the development of the entire self-concept being halted prematurely, leaving the physical self-concept intact, but the psychological self-concept impaired, then it would be predicted that the ownership effect would also be intact since this emerges before the point at which the impairment in ASD has been suggested to happen. However, since this was not the case, we can therefore theorize that the psychological self-concept is a separate cognitive construct which is impaired from the beginning in ASD. If the physical self-concept and the psychological self-concept are distinct cognitive entities then this would allow the physical self-concept to continue to develop independently of the impaired psychological self-concept.

In conclusion, the current study demonstrates a robust self-referent effect using the ownership task in adults without ASD which is severely impaired in participants diagnosed with ASD. The strength of the effect is not dependent self-awareness as measured by the PSC but does correlate with ASD traits as measured by the AQ, even within the TD population. This sheds light both on the nature of the self-concept in ASD and the relationship between the sense of self and the self-reference effect seen within the ownership effect.



# Chapter Eight: General Discussion

## Summary of Results

The basis for this thesis was the hypothesis that, firstly, the physical self-concept remains intact in ASD, while the psychological self-concept does not and, secondly, that there is a distinction between the physical self-concept and the psychological self-concept. In general, the results gathered seem to support these two ideas. Seven experimental chapters have been presented, four describing work with adults and three describing work with children. Chapters 2, 3, 5, and 6 concentrated on differences between the physical self-concept and the psychological self-concept, while chapter 4 concentrated on the physical self-concept in isolation and chapter 7 concentrated on the psychological self-concept in isolation.

In chapter 1, the presence of the self-referencing effect in both the physical and the psychological domain was demonstrated in a typically developing population. To our knowledge, this is the first time that the self-reference effect has been considered in terms of physical and psychological domains. Chapter 2 then employed the same paradigm in a population with ASD. In this group, the self-reference effect was present in both domains, but presented differently in each; self-referencing was reduced in the physical domain and enhanced in the psychological domain. This enhanced processing in the psychological domain was driven, not by increased self-referent processing, but by decreased other referent processing.

The results of chapter 2 led us on to a consideration of the self-concept in children aged 7 – 10 years. The reasons for conducting the study with children were twofold; firstly, we suggested that the relatively good memory for self-referent psychological words

seen in the adults with ASD may have occurred because people with ASD often learn their own personality traits by rote. It is likely that the children would have yet to do this. Secondly, the potential impairment of the psychological self-concept in the adult group means that the development of the psychological self-concept may be somewhat delayed in children. For this reason we decided to work with children aged between seven and ten as typically developing children of this age will have a psychological self-concept, but it will have only recently developed, thus allowing us to investigate any potential developmental delay in the group with ASD. We found that the children without ASD demonstrated the self-referencing effect in both the physical and psychological domains, while the children with ASD displayed a reduced self-referencing effect in the physical domain and an absence of the self-referencing effect in the psychological domain. This suggests again that there may be an impairment of the psychological self-concept in ASD and that the onset of the development of the physical self-concept may be delayed.

Chapter 4 sought to confirm that the physical self-concept was intact in ASD by using the rubber hand illusion. In general, children in the ASD and TD groups displayed approximately the same pattern of results and both groups were vulnerable to the illusion. Having verified the presence of the physical self-concept in ASD, we then returned to examining the potential differences in the nature of the physical and the psychological self-concept in ASD.

The interviews presented in chapter 5 also revealed differences in cognitive processing between the physical and psychological domains within the ASD group. Physical memories were generated more easily and incorporated greater amounts of detail than psychological memories. Physical memories also tended to be more specific than

psychological memories. In general, a similar pattern of responses (with a focus on similar kinds of details) was seen amongst both ASD and TD groups in the physical domain. In the psychological domain, however, responses between the groups differed; the ASD group gave more factual and semantic details than the TD group and some of their responses had a generic or rote learned feel.

In chapter 6, the children completed a similar task to the interview study. They were asked to complete 15 self-descriptive statements. Children in the TD group generated almost equal numbers of physical and psychological statements, whilst children in the ASD group generated predominantly physical statements. The same pattern of responses in the physical domain (in terms of the various kinds of details given) was observed in both groups, but a different pattern of responses was observed in the psychological domain with the TD group making far more statements related to personality than the ASD group.

All the results so far seem to suggest that there is an impairment in the psychological self-concept in ASD. The implication here is that the physical self-concept and the psychological self-concept are distinct cognitive entities since one can be largely intact whilst the other is not. However, it may be that the self-concept is one cognitive construct which grows, changes and evolves, becoming less physical and more psychological over time. According to this argument, the development of the self-concept as a whole becomes impaired at some point shortly before the age of seven (when the shift from the physical to the psychological occurs) in ASD. In order to test whether or not this was the case, we examined the ownership effect in ASD, since the sense of ownership is a facet of the psychological self-concept which emerges well before the age of seven. If the self-concept is one construct which is impaired at a

certain point in development then the ownership effect should be present in ASD.

Whereas, if the psychological self-concept is something separate which is impaired from birth, then the sense of ownership should not be present in ASD.

Chapter 7 examined the ownership effect in adults with and without ASD. The group without ASD showed the ownership effect, while the group with ASD did not, suggesting again that there is an impairment in the psychological self-concept. Importantly, this also suggested that the physical self-concept and the psychological self-concept may be separate cognitive constructs since the psychological self-concept appears to be impaired at a very early point in developmental time while the physical self-concept remains intact at the equivalent age.

### **The Physical Self-Concept in ASD**

A wide body of evidence suggests that the physical self-concept remains largely intact in ASD. Studies of mirror self-recognition, the most basic test of the physical self-concept, have shown that, while children with ASD may develop mirror recognition abilities at a later chronological age than their non-autistic peers, they tend to develop these skills at approximately the same mental age as children who do not have ASD (Ferrari & Matthews, 1983). Mirror recognition abilities are therefore considered to be something of a strength in ASD.

More complex aspects of the physical self-concept have also been shown to be unimpaired. Children with ASD are able to recognise delayed video images of themselves, thus demonstrating an understanding of a temporally extended sense of self (Lind & Bowler, 2009) which places them firmly at the more sophisticated end of the developmental trajectory of the physical self-concept.

The results from the current group of studies (in particular, experiments 4.2, 5.1 and 6.2) seem to largely support the idea that adults and children with ASD have a relatively intact physical self-concept. In particular, the interview study with adults and the statement completion task with children seem to support this view. In the interview study, the answers which adults with ASD gave in response to physical cue words were almost indistinguishable in terms of their specificity and level and type of detail to answers given by the TD group in response to the same cue words. If the physical self-concept is indeed intact in ASD then this result is entirely expected.

In the statement completion task, when physical statements were considered in isolation from psychological statements, the pattern of results in the group with ASD was identical in terms of the level and type of detail given to the pattern of results seen in the TD group. The pattern of results revealed the presence of a large proportion of action statements compared to the proportion of statements concerning, for example, body image and gender. This prevalence of action statements indicates that the children had a fairly complex physical self-concept which encompassed ideas of both the self as a physical being and the self as an agent of action. In other words, by the age of eight, the TD group and ASD group appeared to be at the same stage as far as the development of the physical self-concept was concerned. Age did not affect response pattern in either age group which suggests both that the physical self-concept does not develop dramatically between the ages of 8 and 10 and that this slow rate of development is common to both children with and children without ASD. These results are consistent with the framework for the development of the self-concept which was laid out by Damon and Hart (1988). They suggested that, by the age of seven or eight, children would have reached the second (and final physical) stage of self-concept development

in which the self is seen mainly as an agent of action. In light of this, it is not surprising that the majority of physical statements made by both groups had to do with actions rather than descriptions.

Perhaps more surprising are the results from the three self-referencing studies (chapters 2, and 3). Amongst the populations with ASD, we found that the physical self-referencing effect was somewhat reduced when compared to the comparison group. This finding is in line with the results of several other studies of the self-referencing effect in ASD; Lombardo, Barnes, Wheelwright and Baron-Cohen (2007) and Henderson (2009) both found that the self-referencing effect was reduced amongst populations with ASD. However, their results cannot be directly compared to the results seen here; they failed to distinguish between physical and psychological trait adjectives and therefore reported only a general self-referencing effect.

Given these results, the physical self-concept may be partially impaired in ASD. However, the results of the interview studies which, arguably, are ‘purer’ measures of the self-concept (the statement completion task in particular since it does not rely on autobiographical memory or any other additional cognitive process), suggest that any potential impairment in the physical self-concept is slight.

### **The Psychological Self-Concept in ASD**

This thesis started out by positing that the psychological self-concept was impaired in ASD. Although, the psychological self-concept has never really been directly assessed in people with ASD, there is evidence to suggest that it may be impaired (Neisser, 1998). A lot of this evidence is indirect, but nonetheless compelling. For example, the difficulties relating to others seen in ASD may be traced back to an impaired psychological self-concept along with difficulties using first and second person

pronouns (Toichi et al, 2002). There is also a prevalence of alexithymia (a lack of awareness of one's own emotions) in ASD (Shalom et al, 2006) and a tendency towards rote learning of one's own psychological traits (Lee & Hobson, 1998).

The results presented in chapters 5 and 6 provide compelling evidence for an impairment of the psychological self-concept in ASD. The interview study presented in chapter 5 shows that people with ASD generate fewer autobiographical memories when prompted with psychological cue words than when they are prompted with physical cue words. This is not the case within the neurotypical population. The psychological memories which are generated also tend to be less specific and give only sparse detail when compared to more physical memories. There was also a tendency amongst the group with ASD to give a lot of semantic detail, rather than experiential detail. The feeling of reliving a moment which was seen within the TD group was almost entirely absent from the ASD group in the psychological domain. This finding is in keeping with the remember/know distinction proposed by Bowler, Gardiner and Grice (2000). They suggested that people with ASD often recalled semantic information independent of context in a process which was more akin to knowing than remembering. There was a focus on the factual in the ASD group which was absent in the TD group – again this suggests an absence of remembering experiences in the first person and points to a kind of third person recall. All of this is consistent with the idea of an impairment of the psychological self-concept.

The statement completion task provided further convincing evidence for an impairment of the psychological self-concept. Whereas children without ASD provided almost equal numbers of physical and psychological statements, children with ASD provided a far greater number of physical statements. This in itself is indicative of the fact that they

view themselves perhaps more as physical beings than as psychological beings. The TD group generated large numbers of statements which were focused on social relationships and group membership which places them firmly at Damon and Hart's (1988) first stage of development of the psychological self which is where their chronological age would suggest that they should be. The group with ASD made far fewer of these social statements, implying that they may not yet have reached this stage. The group with ASD also made strikingly few statements based around personality (perhaps the most direct measure of the psychological self-concept). Instead, the majority of their psychological statements had to do with preferences (likes and dislikes). This is arguably one of the earliest and least complex facets of the psychological self-concept to emerge; typically developing toddlers will often express preferences (Metcalf & Mischel, 1999). Some of these preference statements may also be a consequence of the repetitive and stereotyped obsessive interests which often characterise ASD.

At first glance, the results of the adult self-referencing study seem to show the opposite pattern of performance to that which would be expected as the self-referencing effect appears to be enhanced in the psychological domain which would point to a strong psychological self-concept. However, when the results are examined in detail, the adults with ASD actually remembered fewer self-referent psychological words than physical words, suggesting instead an impairment of the psychological self-concept. The appearance of an enhanced psychological SRE is driven instead by a striking paucity of other referent processing in the psychological domain. This is consistent both with the idea of an impaired psychological self-concept and with the theory of mind and social interaction deficits commonly seen in ASD (Mundy, Sigman, Ungerer & Sherman, 1986). That people with ASD often demonstrate little interest in other people is not a new finding, what is more interesting is that, on the basis of the self-referencing studies,



we can surmise that people with ASD appear to be more interested in others as physical beings than as psychological beings since there was no equivalent lack of other referent processing in the physical domain. Further evidence for this comes from the fact that very young children with autism are often seen treating people as though they were objects (for example, by using another person's hand as a tool) (Phillips, Gómez, Baron-Cohen, Laá, & Rivière, 1995). This makes sense within the context of simulation theory (Goldman, 2006) which suggests that we base our understanding of our own minds and mental states on the understanding of the minds and mental states of others. If people with ASD have an impairment of the psychological but not the physical self-concept it would therefore be expected that they would show deficits in other-referent psychological, but not physical processing.

The self-referencing study with children presented in chapter 3 yielded an absence of the self-referencing effect in the psychological domain. This again suggests an impairment of the psychological self-concept. It is likely that this effect occurred in the child group, but not in the adult group either because children with ASD have yet to learn their own personality traits by rote in the way that adults with ASD do (Hill, Berthoz & Frith, 2005), or because the onset of the development of the psychological self-concept is delayed in children with ASD.

Another interesting feature of these results is that the impairments seen in the psychological self-concept were present in some form in both the adults and the children studied. One potential account of the self-concept deficits seen in ASD is that the shift from physical to psychological self-awareness which occurs at around the age of seven in typically developing children (Damon & Hart, 1988) does not occur in children with ASD. This account puts forward the idea that the development of the self-

concept is therefore the same in children with and without ASD until they reach a mental age of around seven years. This would mean that any facets of the psychological self-concept which emerge before the age of seven should be intact in children with ASD. Chapter 7 addressed this idea by testing the notion of ownership, an aspect of the psychological self-concept which is present in some form by the age of two (Ross, 1996). Adults with ASD demonstrated no sense of ownership over objects. Therefore, it is not just the shift from physical to psychological self-awareness which is impaired, but the psychological self-concept itself even at its most basic level. This result also leads us to a consideration of whether the psychological and physical self-concepts are two facets of the same thing or two distinct, but highly related, cognitive constructs. These ideas will be discussed in more detail in the section below.

In the introduction section of this thesis, I went into some detail about the idea of theory of mind and its relation to the self-concept. In particular, the relation between theory of mind and theory of own mind was discussed and, it was highlighted, that an issue with the pre-existing literature is the fact that there is a much greater focus on understanding the minds of others as opposed to understanding the mind of the self. The studies presented here add to the literature on theory of own mind and the way in which theory of own mind abilities present in those with ASD. In addition, they consider aspects of the physical self-concept which are not usually discussed in the ToM literature, allowing us to distinguish between the way in which people with ASD conceive of themselves as physical entities and the way in which they conceive of themselves as psychological beings.

### **Are the Physical and Psychological Self-concepts distinct cognitive entities?**

There is a great deal of literature and experimental evidence which suggests that the self-concept has both physical and psychological facets. However, most of the pre-existing evidence traces the developmental trajectory of the self-concept and perhaps implies that the self-concept is a single cognitive construct which grows, evolves and changes over time. In other words, the self-concept begins as something physical in infancy and early childhood and then becomes something which has more psychological aspects.

Early studies such as those conducted by Broughton (1978) would suggest that this is the case. In Broughton's work, the evolution of the self is traced by the very simple idea of asking children what the self is; younger children equate the self with a part of the body while older children do not. Thus, the self-concept changes from the physical to the psychological with no suggestion of concurrent facets developing in tandem.

The first suggestion that the self-concept may have many dimensions simultaneously comes from Damon and Hart (1988). They used the self-understanding interview to outline a four stage development of the self-concept; at stage one, the self-concept is purely physical, at stage two it incorporates ideas of the physical body as an agent of action, at stage three, personality and social relationships become a focus and, by stage four, ethical, moral, political and religious beliefs begin to be explored. On the face of it, this seems to be an evolution of self which is similar to that outlined by Broughton. However, there are differences between the two. Damon and Hart noted that not all of a child's answers would be appropriate to his or her stage of self-concept development. For example, an eight year-old child who gives a majority of stage three responses may still make some references to physical actions (stage two) and personal beliefs (stage four). For Damon and Hart, the self-concept therefore does not change from one thing

into another. Instead, all four aspects of the self-concept are always present, but the dominant aspect changes as the child grows.

From this idea of ever-changing dominant and dormant aspects of the self-concept, it is relatively logical to come to the conclusion that perhaps these various aspects are separate cognitive constructs which become activated at different points in developmental time. This would mean that the psychological and physical self-concepts are distinct from one another to a large extent. This in turn would allow one to be impaired whilst the other remains intact.

The study of autism is key here. It provides a case study of a developmental disorder in which just this happens; the physical self-concept is relatively intact and the psychological self-concept is impaired. All of the results described here would suggest that this is the case, but particular attention should be given to the rubber hand illusion (chapter 4) and the shopping basket task (chapter 7) since one tests the physical self concept and one the psychological self-concept. The performance of the ASD group on the rubber hand illusion, while not quite identical to the performance of the TD group (largely for unrelated sensory reasons), suggests that the physical self-concept is still very much present in ASD. The shopping basket task suggests that the psychological self-concept, by contrast, is impaired. This result is particularly strong as the facet of the self-concept tested by the shopping basket task is one which emerges at a very early point in developmental time. The fact that it is impaired here is indicative of the fact that it is not a shift from the physical to the psychological self-concept at a certain mental or chronological age which is impaired, but rather it is an impairment of a distinct cognitive process at a more basic level. This, more than anything, would seem to lead to the idea that the physical and psychological self-concepts are distinct and

separable entities. The differences in performance in response to physical and psychological cues in chapters 5 and 6 give further weight to this argument.

### **Limitations of the Methodology**

Working with children presents a methodological challenge, particularly children with ASD who often have communication difficulties. Tasks necessarily had to be shortened and simplified (most notably the self-referencing task). The adult interview task also had to be simplified and shortened into the statement completion task to make it suitable for use with children. Unfortunately, this necessary simplification made a direct comparison between participant performance on the two tasks difficult.

In both the adult and the child populations, every effort was made to ‘match’ the TD and ASD groups in terms of gender, age and IQ. With the adult groups, this matching was highly successful. However, with the child groups, it proved something of a logistical challenge due to the administrative difficulties inherent in working in schools and finding children with a diagnosis of ASD. This led to certain compromises having to be made. Eventually, the child groups were matched on age and IQ, but were not closely matched on gender, with more females in the TD group than in the ASD group. It was decided not to match on gender after it became apparent that matching on all three factors would be impossible and after analyses of the data from the larger TD samples showed that gender had no effect on task performance. These analyses were repeated on the (unmatched in terms of gender) ASD and TD comparison groups. Again, gender was found to have had no effect on task performance.

A particular problem for the rubber hand study arises from the fact that 70% of people with a diagnosis of ASD have some kind of sensory difficulty ranging from

hyposensitivity to hypersensitivity in a variety of different sensory domains (Leekam, Nieto, Libby, Wing & Gould, 2007). As the rubber hand illusion is a sensory illusion, these sensory difficulties may have influenced results. Different individuals with ASD do not display the same sensory difficulties which means that it is somewhat difficult to factor them out during a statistical analysis or experimental task (for example some individuals may display hyposensitivity to a particular stimulus while others display hypersensitivity to the same stimulus). Individuals with ASD also show a preference for proximal (touch, taste and smell) over distal (sight and hearing) sensory information as opposed to the typical preference for distal over proximal sensory information (Masterton & Biederman, 1983). Again, this may have had an effect on the results of the rubber hand illusion since vulnerability to the illusion depends in part on a preference for distal over proximal sensory information, especially for the preferential processing of visual information over tactile information. The fact that the ASD group showed vulnerability to the illusion at all under these circumstances is perhaps a testament to the strength of the physical self-concept present rather than otherwise.

### **Analytical Issues**

The decision was made to use corrected hit rates instead of reporting  $d'$  prime throughout the analyses in chapters 1, 2, 3 and 7. This was done for comparison purposes because the majority of the existing literature which utilises similar methodologies uses corrected hit rates rather than  $d'$  prime. It was therefore felt that it would be easier to compare our results with pre-existing results if corrected hit rates were used. As a precaution,  $d'$  prime values were calculated for all data sets and all analyses were repeated using these values. However, analysis using  $d'$  prime produced identical results in all cases to analysis using corrected hit rates (i.e., all effects that were significant using corrected hit rate were also significant when using  $d'$  prime and, vice

versa, all effects that were non-significant using corrected hit rate were also non-significant when using  $d'$  prime). Therefore, for the sake of brevity (and to allow for direct comparison with previous studies) the  $d'$  prime analyses are not included here.

One issue with using categorical analysis is that it is sometimes difficult to tell from the results generated, how large the differences between groups are, since categorical analysis works by simply stating whether a value is smaller or greater than a given value. I have attempted to overcome this problem here by including breakdowns of the categorical analyses in each chapter which detail exactly how large the group differences were (see tables 1.2, 2.3, 2.7, 3.3, 3.6, 4.3, 4.6, 7.2 and 7.6.)

### **Future Research Directions**

The results presented here suggest firstly that ASD leads to an impairment of the psychological self-concept while leaving the physical self-concept intact and, secondly, that the physical and psychological self-concepts can be seen as separate dissociable entities which develop in tandem. Both of these results are worthy of further investigation.

It would be interesting to consider in more detail the developmental trajectories of both the physical and the psychological self-concepts. For example, this thesis does not consider whether or not the development of the physical self-concept is delayed in ASD (although evidence from mirror recognition studies would suggest that it is). It would also be interesting to trace the development of the psychological self-concept throughout later childhood and into adolescence in a group of children with ASD and a group of children without.

The physical and psychological self-concepts are also worth further investigation within the typically developing population. It would be interesting to consider whether or not the strength of the self-concept in either domain is linked to various personality traits such as empathy.

I began this thesis by saying that the self-concept is a cognitive construct which has far-reaching consequences. Indeed, it is unique among cognitive constructs because it impacts on almost every area of cognition. As Hume suggested in 1739, we are unable to think about ourselves without considering our perceptions of the self. Similarly, our perceptions of the self directly influence the ways we perceive the environments in which we find ourselves, from directing our attention towards certain stimuli and away from others to affecting the way in which we interpret the actions and intentions of others. Therefore, understanding the nature of the self-concept in autism spectrum disorders may help elucidate other areas of cognition, which may in turn have important clinical and educational implications.



## References

- Abrahams, B. S., & Geschwind, D. H. (2008). Advances in autism genetics: on the threshold of a new neurobiology. *Nature Reviews Genetics*, 9(5), 341-355.
- American Psychiatric Association, (2000). *Diagnostic and Statistical Manual-Text Revision (DSM-IV-TR*im, 2000).
- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.
- Amsterdam, B. (1972). Mirror self-image reactions before age two. *Developmental Psychobiology*, 5(4), 297-305.
- Anderson, N. H. (1968). Likableness ratings of 555 personality-trait words. *Journal of personality and social psychology*, 9(3), 272.
- Anderson, E. M., Bohon, L. M., & Berrigan, L. P. (1996). Factor structure of the private self-consciousness scale. *Journal of Personality Assessment*, 66(1), 144-152.
- Annaz, D., Campbell, R., Coleman, M., Milne, E., & Swettenham, J. (2012). Young children with autism spectrum disorder do not preferentially attend to biological motion. *Journal of autism and developmental disorders*, 42(3), 401-408.
- Annaz, D., Remington, A., Milne, E., Coleman, M., Campbell, R., Thomas, M. S., & Swettenham, J. (2010). Development of motion processing in children with autism. *Developmental science*, 13(6), 826-838.
- Baron-Cohen, S. (1991). Precursors to a theory of mind: Understanding attention in others.
- Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a “theory of mind”? *Cognition*, 21(1), 37-46.
- Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of autism and developmental disorders*, 31(1), 5-17

- Bauminger, N., & Kasari, C. (1999). Brief report: Theory of mind in high-functioning children with autism. *Journal of Autism and Developmental Disorders*, 29(1), 81-86.
- Beggan, J. K. (1992). On the social nature of nonsocial perception: The mere ownership effect. *Journal of Personality and Social Psychology*, 62(2), 229.
- Belk, R.W The ineluctable mysteries of possessions *Journal of Social Behavior and Personality*, 6 (1991),17–55
- Bennetto, L., Pennington, B. F., & Rogers, S. J. (1996). Intact and impaired memory functions in autism. *Child development*, 67(4), 1816-1835.
- Bettelheim, B. (1967). *Empty fortress*. Simon and Schuster.
- Bleuler, E. (1905). *Dementia Praecox or The Group of Schizophrenias*. New York: International Universities Press.
- Bonath, B., Noesselt, T., Martinez, A., Mishra, J., Schwiecker, K., Heinze, H. J., & Hillyard, S. A. (2007). Neural basis of the ventriloquist illusion. *Current Biology*, 17(19), 1697-1703.
- Botvinick, M., & Cohen, J. (1998). Rubber hands' feel'touch that eyes see. *Nature*, 391(6669), 756-756.
- Boucher, J. (1981). Memory for recent events in autistic children. *Journal of Autism and Developmental Disorders*, 11(3), 293-301.
- Boucher, J., & Lewis, V. (1989). Memory impairments and communication in relatively able autistic children. *Journal of Child Psychology and Psychiatry*, 30(1), 99-122.
- Boucher, J., & Lewis, V. (1992). Unfamiliar Face Recognition in Relatively Able Autistic Children. *Journal of Child Psychology and Psychiatry*, 33(5), 843-859.
- Bowler, D. M., Gardiner, J. M., & Grice, S. J. (2000). Episodic Memory and Remembering in Adults with Asperger Syndrome. *Journal of Autism and Developmental Disorders*, 30(4), 295-304.

- Bowler, D. M., Gardiner, J. M., & Berthollier, N. (2004). Source memory in adolescents and adults with Asperger's syndrome. *Journal of Autism and Developmental Disorders*, 34(5), 533-542.
- Broughton, J. (1978). Development of concepts of self, mind, reality, and knowledge. *New Directions for Child and Adolescent Development*, 1978(1), 75-100.
- Butterworth, G. (1995). An ecological perspective on the origins of the self. The body and the self. In Bermúdez, A. J.; Eilan, N. (Ed.), *The body and the self* (pp. pp.87-105). Cambridge, MA, US: The MIT Press.
- Carpenter, M., Pennington, B. F., & Rogers, S. J. (2001). Understanding of others' intentions in children with autism. *Journal of autism and developmental disorders*, 31(6), 589-599.
- Carruthers, P. (2009). How we know our own minds: The relationship between mindreading and metacognition. *Behavioral and brain sciences*, 32(02), 121-138.
- Cascio, C. J., Foss-Feig, J. H., Burnette, C. P., Heacock, J. L., & Cosby, A. A. (2012). The rubber hand illusion in children with autism spectrum disorders: delayed influence of combined tactile and visual input on proprioception. *Autism*, 16(4), 406-419.
- Cascio, C., McGlone, F., Folger, S., Tannan, V., Baranek, G., Pelphrey, K. A., & Essick, G. (2008). Tactile perception in adults with autism: a multidimensional psychophysical study. *Journal of autism and developmental disorders*, 38(1), 127-137
- Cohen, R. L. (1989). Memory for action events: The power of enactment. *Educational Psychology Review*, 1(1), 57-80.
- Costantini, M., & Haggard, P. (2007). The rubber hand illusion: sensitivity and reference frame for body ownership. *Consciousness and cognition*, 16(2), 229-240.
- Constantino JN, Gruber CP. (2005). *The social responsiveness scale manual*. Los Angeles, CA: Western Psychological Services
- Constantino, J. N., Davis, S. A., Todd, R. D., Schindler, M. K., Gross, M. M., Brophy, S. L., ... & Reich, W. (2003). Validation of a brief quantitative measure of autistic traits:

- comparison of the social responsiveness scale with the autism diagnostic interview-revised. *Journal of autism and developmental disorders*, 33(4), 427-433.
- Constantino, J. N. (2011). The quantitative nature of autistic social impairment. *Pediatric research*, 69, 55R-62R.
- Constantino, J. N., & Todd, R. D. (2005). Intergenerational transmission of subthreshold autistic traits in the general population. *Biological psychiatry*, 57(6), 655-660.
- Conway, M. A., & Rubin, D. C. (1993). The structure of autobiographical memory. *Theories of memory*, 103-137.
- Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review*, 107(2), 261.
- Crane, L., & Goddard, L. (2008). Episodic and Semantic Autobiographical Memory in Adults with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, 14, 383-394.
- Crawley, R. A., & Eacott, M. J. (2006). Memories of early childhood: Qualities of the experience of recollection. *Memory & cognition*, 34(2), 287-294.
- Cunningham, S. J., Turk, D. J., Macdonald, L. M., & Macrae, C.N. (2008). Yours or mine? Ownership and memory. *Consciousness and cognition*, 17(1), 312-318.
- Cunningham, S. J., Vergunst, F., Macrae, C. N., & Turk, D. J. (2012). Exploring early self-referential memory effects through ownership. *British Journal of Developmental Psychology*
- Damon, W. (1991). *Self-understanding in childhood and adolescence* (No. 7). CUP Archive.
- Damon, W., & Hart, D. (1982). The Development of Self-Understanding from Infancy Through Adolescence. *Child Development*, 53(4), 841-864.
- Damon, W., & Hart, D. (1986). Stability and change in children's self-understanding. *Social Cognition*, 4(2), 102-118.

- Damon, W., & Hart, D. (1988). *Self-Understanding in Childhood and Adolescence*. Cambridge: Cambridge University Press.
- Darwin, C. (1877). A biographical sketch of an infant. *Mind*, 2, 285 - 294.
- Dixon, J. C. (1957). Development of self recognition. *Journal of General Psychology*, 91, 251-256.
- Driver, J., & Spence, C. (1998). Attention and the crossmodal construction of space. *Trends in cognitive sciences*, 2(7), 254-262.
- Eacott, M. J., & Crawley, R. A. (1998). The offset of childhood amnesia: memory for events that occurred before age 3. *Journal of Experimental Psychology: General*, 127(1), 22.
- Ehrsson, H. H., Holmes, N. P., & Passingham, R. E. (2005). Touching a rubber hand: feeling of body ownership is associated with activity in multisensory brain areas. *The Journal of Neuroscience*, 25(45), 10564-10573.
- Ehrsson, H. H., Spence, C., & Passingham, R. E. (2004). That's my hand! Activity in premotor cortex reflects feeling of ownership of a limb. *Science*, 305(5685), 875-877.
- Einstein, G. O., & Hunt, R. R. (1980). Levels of processing and organization: Additive effects of individual-item and relational processing. *Journal of Experimental Psychology: Human Learning and Memory*, 6(5), 588-598.
- El-Sheikh, M., Cummings, E. M., & Goetsch, V. L. (1989). Coping with adults' angry behavior: Behavioral, physiological, and verbal responses in preschoolers. *Developmental Psychology*, 25(4), 490.
- Engelkamp, J. (1991). *Memory of action events: Some implications for memory theory and for imagery*: Springer
- Erikson, E. H. (1980). *Identity and the life cycle* (Vol. 1). WW Norton & Company.
- Farley, A., Lopez, B., & Saunders, G. (2010). Self-conceptualisation in autism Knowing oneself versus knowing self-through-other. *Autism*, 14(5), 519-530.

- Fasig, 2000, Toddlers' understanding of ownership: Implications for self-concept development  
*Social Development*, 9 (2000), 370–382
- Feinberg, T. E., Haber, L. D., & Leeds, N. E. (1990). Verbal asomatognosia. *Neurology*, 40(9), 1391-1391.
- Fenigstein, A., Scheier, M. F., & Buss, A. H. (1975). Public and private self-consciousness: Assessment and theory. *Journal of consulting and clinical psychology*, 43(4), 522.
- Ferrari, M., & Matthews, W. S. (1983). Self-recognition deficits in autism: Syndrome-specific or general developmental delay? *Journal of Autism and Developmental Disorders*, 13(3), 317-324.
- Fisher, N., & Happé, F. (2005). A training study of theory of mind and executive function in children with autistic spectrum disorders. *Journal of autism and developmental disorders*, 35(6), 757-771.
- Frith, U., & Happé, F. (1994). Autism: Beyond “theory of mind”. *Cognition*, 50(1), 115-132.
- Frith, U. (2003). Autism: Explaining the Enigma. Malden, Blackwell Publishing.
- Gallagher, S. (2000). Philosophical conceptions of the self: implications for cognitive science. *Trends in cognitive sciences*, 4(1), 14-21.
- Gillihan, S. J., & Farah, M. J. (2005). Is Self Special? A Critical Review of Evidence From Experimental Psychology and Cognitive Neuroscience. *Psychological Bulletin*, 131(1), 76-97.
- Goddard, L., Dritschel, B., & Burton, A. (1996). Role of autobiographical memory in social problem solving and depression. *Journal of Abnormal Psychology*, 105(4), 609.
- Goddard, L., Howlin, P., Dritschel, B., & Patel, T. (2007). Autobiographical memory and social problem-solving in Asperger syndrome. *Journal of Autism and Developmental Disorders*, 37(2), 291-300.
- Goldman, A. I. (1992). In defense of the simulation theory. *Mind & Language*, 7(1-2), 104-119.

- Goldman, A. (2006). *Simulating Minds: The philosophy, psychology and neuroscience of mindreading*. New York: Oxford University Press
- Grainger, C., Williams, D. M., & Lind, S. E. (2013). Online action monitoring and memory for self-performed actions in autism spectrum disorder. *Journal of autism and developmental disorders*, 1-14.
- Greenspan, S. I., & Weider, S. (1997). Developmental patterns and out-comes in infants and children with disorders in relating and communicating. *Journal of Developmental and Learning Disorders*, 1,28-37.
- Groh, J. M., & Sparks, D. L. (1996). Saccades to somatosensory targets. I. Behavioral characteristics. *Journal of Neurophysiology*, 75(1), 412-427.
- Guardo, C. J., & Bohan, J. B. (1971). Development of a Sense of Self-Identity in Children. *Child Development*, 42(6), 1909-1921.
- Hammen, C., & Zupan, B. A. (1984). Self-schemas, depression, and the processing of personal information in children. *Journal of Experimental Child Psychology*, 37(3), 598-608.
- Happé, F. (1991). The autobiographical writings of three Asperger syndrome adults: Problems of interpretation and implications for theory. *Autism and Asperger syndrome*, 207-242.
- Happé, F. (1999). Autism: cognitive deficit or cognitive style?. *Trends in cognitive sciences*, 3(6), 216-222.
- Harley, K., & Reese, E. (1999). Origins of Autobiographical Memory. *Developmental Psychology*, 35(5), 1338-1348
- .Heaton, P., Reichenbacher, L., Sauter, D., Allen, R., Scott, S., & Hill, E. (2012). Measuring the effects of alexithymia on perception of emotional vocalizations in autistic spectrum disorder and typical development. *Psychological medicine*, 42(11), 2453-2459.
- Henderson, H. A., Zahka, N. E., Kojkowski, N. M., Inge, A. P., Schwartz, C. B., Hileman, C. M., et al. (2009). Self-referenced memory, social cognition, and symptom presentation in autism. *Journal of Child Psychology and Psychiatry*, 50(7), 853-861.

- Herbert, J. D., Sharp, I. R., & Gaudiano, B. A. (2002). Separating fact from fiction in the etiology and treatment of autism: A scientific review of the evidence. *Scientific Review of Mental Health Practice*, 1(1), 23-43.
- Hobson, J. & Bowler, D.M. (Eds.) (2010). The self in autism [Special issue]. *Autism*, 14(5).
- Hermelin, B., & Frith, U. (1991). Psychological studies of childhood autism: can autistic children make sense of what they see and hear?. *Focus on Autistic Behavior*.
- Hill, E., Berthoz, S., & Frith, U. (2004). Brief report: Cognitive processing of own emotions in individuals with autistic spectrum disorder and in their relatives. *Journal of autism and developmental disorders*, 34(2), 229-235.
- Hirstein, W., Iversen, P., & Ramachandran, V. S. (2001). Autonomic responses of autistic children to people and objects. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 268(1479), 1883-1888.
- Hobson, R. P. (1995). *Autism and the development of mind*. Psychology Press.
- Hobson, R. P. (2010). Explaining autism Ten reasons to focus on the developing self. *Autism*, 14(5), 391-407
- Hobson, R. P., Chidambi, G., Lee, A., & Meyer, J. (2006). Foundations for self-awareness: An exploration through autism. Monographs of the Society for Research in Child Development, Serial no. 284, Vol. 71.
- Hobson, R. P., & Lee, A. (1999). Imitation and identification in autism. *Journal of Child Psychology and Psychiatry*, 40(04), 649-659.
- Howe, M. L., & Courage, M. L. (1997). The Emergence and Early Development of Autobiographical Memory. *Psychological Review*, 104(3), 499-523.
- Hume, D. (1978). 1739. A treatise of human nature. *London: John Noon*.
- Hurlburt R, Happe´ F, Frith U. Sampling the form of inner experience in three adults with asperger syndrome. *Psychol Med* 1994; 24: 385–395.



- IJsselsteijn, W. A., de Kort, Y. A. W., & Haans, A. (2006). Is this my hand I see before me? The rubber hand illusion in reality, virtual reality, and mixed reality. *Presence: Teleoperators and Virtual Environments*, 15(4), 455-464.
- James, W. (1890). *The Principles of Psychology*. 1, 697.
- Kahneman, D., Knetsch, J. L., Thaler, R. The endowment effect, loss aversion and status quo bias *Journal of Economic Perspectives*, 5 (1991), pp. 193–206
- Kammers, M. P. M., de Vignemont, F., Verhagen, L., & Dijkerman, H. C. (2009). The rubber hand illusion in action. *Neuropsychologia*, 47(1), 204-211.
- Keenan, J. M. (1993). An exemplar model can explain Klein and Loftus' results. In T. K. Srull & R. S. Wyer (Eds.), *Advances in Social Cognition* (Vol. 5, pp. 69-77). Hillsdale: Erlbaum.
- Keller, A., Ford, L. H., & Meacham, J. A. (1978). Dimensions of self-concept in preschool children. *Developmental Psychology*, 14(5), 483-489.
- Kern, J. K., Trivedi, M. H., Garver, C. R., Grannemann, B. D., Andrews, A. A., Savla, J. S., ... & Schroeder, J. L. (2006). The pattern of sensory processing abnormalities in autism. *Autism*, 10(5), 480-494.
- Kihlstrom, J. F., Albright, J. S., Klein, S. B., Cantor, N., Chew, B. R., Niedenthal, P. M., et al. (1988). Information Processing and the Study of the Self *Advances in Experimental Social Psychology* (Vol. Volume 21, pp. 145-178): Academic Press.
- Klein, S. B., & Loftus, J. (1988). The nature of self-referent encoding: The contributions of elaborative and organizational processes. *Journal of Personality and Social Psychology*, 55(1), 5.
- Klein, S. B., Chan, R. L., & Loftus, J. (1999). Independence of Episodic and Semantic Self-Knowledge: The Case from Autism. *Social Cognition*, 17(4), 413-436.
- Klein, S. B., Loftus, J., & Burton, H. A. (1989). Two Self-Reference Effects: The Importance of Distinguishing Between Self-Descriptiveness Judgments and Autobiographical

- Retrieval in Self-Referent Encoding. *Journal of Personality and Social Psychology*, 56(6), 853-865.
- Kuiper, N. A., & Derry, P. A. (1982). Depressed and nondepressed content self-reference in mild depressives. *Journal of Personality*, 50(1), 67-80.
- Lau, H. C., Rogers, R. D., Haggard, P., & Passingham, R. E. (2004). Attention to intention. *Science*, 303(5661), 1208-1210.
- Lee, A., & Hobson, R. P. (1998). On Developing Self-concepts: A Controlled Study of Children and Adolescents with Autism. *Journal of Child Psychology and Psychiatry*, 39(8), 1131-1144.
- Lee, A., Hobson, R. P., & Chiat, S. (1994). I, you, me, and autism: An experimental study. *Journal of Autism and Developmental Disorders*, 24, 155–176.
- Leekam, S. R., Nieto, C., Libby, S. J., Wing, L., & Gould, J. (2007). Describing the sensory abnormalities of children and adults with autism. *Journal of autism and developmental disorders*, 37(5), 894-910.
- Leslie, A. M., & Roth, D. (1993). What autism teaches us about metarepresentation.
- Leslie, A. M., & Thaiss, L. (1992). Domain specificity in conceptual development: Neuropsychological evidence from autism. *Cognition*, 43(3), 225-251.
- Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: dissociating episodic from semantic retrieval. *Psychology and aging*, 17(4), 677.
- Lewis, M., & Brooks-Gunn, J. (1979). *Social Cognition and the Acquisition of Self*. New York: Plenum Press.
- Lewis, M., Sullivan, M. W., & Brooks-Gunn, J. (1985). Emotional behaviour during the learning of a contingency in early infancy. *British Journal of Developmental Psychology*, 3(3), 307-316.

- Lind, S., & Bowler, D. (2009). Recognition Memory, Self-Other Source Memory, and Theory-of-Mind in Children with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, 39(9), 1231-1239.
- Lind, S. E. (2010). Memory and the self in autism A review and theoretical framework. *Autism*, 14(5), 430-456.
- Lind, S. E., Williams, D. M., Bowler, D. M., & Peel, A. (2014). Episodic memory and episodic future thinking impairments in high-functioning autism spectrum disorder: An underlying difficulty with scene construction or self-projection?. *Neuropsychology*, 28(1), 55.
- Llobera, J., Sanchez-Vives, M. V., & Slater, M. (2013). The relationship between virtual body ownership and temperature sensitivity. *Journal of The Royal Society Interface*, 10(85)
- Lombardo, M. V., Barnes, J. L., Wheelwright, S. J., & Baron-Cohen, S. (2007). Self-referential cognition and empathy in autism. *PLoS One*, 2(9), e883.
- Lombardo, M. V., Chakrabarti, B., Bullmore, E. T., Wheelwright, S. J., Sadek, S. A., Suckling, J., et al. (2009). Shared Neural Circuits for Mentalizing about the Self and Others. *Journal of cognitive neuroscience*, 22(7), 1623 - 1635.
- Lord, C., Risi, S., Lambrecht, L., Cook Jr, E. H., Leventhal, B. L., DiLavore, P. C., ... & Rutter, M. (2000). The Autism Diagnostic Observation Schedule—Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of autism and developmental disorders*, 30(3), 205-223.
- Losh, M., & Capps, L. (2003). Narrative Ability in High-Functioning Children with Autism or Asperger's Syndrome. *Journal of Autism and Developmental Disorders*, 33(3), 239-251
- Loveland, K. A., & Landry, S. H. (1986). Joint attention and language in autism and developmental language delay. *Journal of Autism and Developmental Disorders*, 16(3), 335-349.

- Mackintosh, B., & Mathews, A. (2003). Don't look now: Attentional avoidance of emotionally valenced cues. *Cognition & Emotion*, 17(4), 623-646.
- Mathews, A., & MacLeod, C. (2005). Cognitive vulnerability to emotional disorders. *Annual Review of Clinical Psychology*, 1, 167–195.
- Markus, H., & Nurius, P. (1986). Possible Selves. *American Psychologist*, 41(9), 954-969
- Masterton, B. A., & Biederman, G. B. (1983). Proprioceptive versus visual control in autistic children. *Journal of Autism and Developmental Disorders*, 13(2), 141-152.
- Mathews, A., & MacLeod, C. (2005). Cognitive vulnerability to emotional disorders. *Annual review of clinical psychology*, 1, 167-195.
- Metcalf, J., & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: dynamics of willpower. *Psychological review*, 106(1), 3.
- Meyer, J. A., & Hobson, R. P. (2004). Orientation in relation to self and other: The case of autism. *Interaction Studies*, 5(2), 221-244.
- Millward, C., Powell, S., Messer, D., & Jordan, R. (2000). Recall for self and other in autism: Children's memory for events experienced by themselves and their peers. *Journal of Autism and Developmental Disorders*, 30(1), 15-28.
- Mittal, B., & Balasubramanian, S. K. (1987). Testing the dimensionality of the self-consciousness scales. *Journal of Personality Assessment*, 51(1), 53-68.
- Mon-Williams, M., Wann, J. P., Jenkinson, M., & Rushton, K. (1997). Synaesthesia in the normal limb. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 264(1384), 1007-1010.
- Moran, J. M., Macrae, C. N., Heatherton, T. F., Wyland, C. L., & Kelley, W. M. (2006). Neuroanatomical evidence for distinct cognitive and affective components of self. *Journal of cognitive neuroscience*, 18(9), 1586-1594.

- Müller, U., Zelazo, P. D., & Imrisek, S. (2005). Executive function and children's understanding of false belief: How specific is the relation?. *Cognitive Development*, 20(2), 173-189.
- Mundy, P., Sigman, M., Ungerer, J., & Sherman, T. (1986). Defining the social deficits of autism: the contribution of non-verbal communication measures. *Journal of child psychology and psychiatry*, 27(5), 657-669.
- Neisser, U. (1988). Five kinds of self-knowledge. *Philosophical psychology*, 1(1), 35-59.
- Nielsen, M., & Dissanayake, C. (2004). Pretend play, mirror self-recognition and imitation: a longitudinal investigation through the second year. *Infant Behavior and Development*, 27(3), 342-365.
- Northoff, G., Heinzel, A., de Greck, M., Bermpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain—a meta-analysis of imaging studies on the self. *Neuroimage*, 31(1), 440-457.
- O’Riordan, M., & Passetti, F. (2006). Discrimination in autism within different sensory modalities. *Journal of autism and developmental disorders*, 36(5), 665-675.
- Ozonoff, S., & McEvoy, R. E. (1994). A longitudinal study of executive function and theory of mind development in autism. *Development and psychopathology*, 6(03), 415-431.
- Papoušek, H., & Papoušek, M. (1975). Cognitive aspects of preverbal social interaction between human infants and adults. In *Ciba Foundation Symposium 33-Parent-Infant Interaction* (pp. 241-269). John Wiley & Sons, Ltd.
- Paton, B., Hohwy, J., & Enticott, P. G. (2012). The rubber hand illusion reveals proprioceptive and sensorimotor differences in autism spectrum disorders. *Journal of autism and developmental disorders*, 42(9), 1870-1883.
- Patterson, F. G., & Cohn, R. H. (2006). 17 Self-recognition and self-awareness in lowland gorillas. *Self-awareness in animals and humans: Developmental perspectives*, 273.

- Pavani, F., Spence, C., & Driver, J. (2000). Visual capture of touch: Out-of-the-body experiences with rubber gloves. *Psychological Science, 11*(5), 353-359.
- Perner, J., & Ruffman, T. (1995). Episodic Memory and Autonoetic Consciousness: Developmental Evidence and a Theory of Childhood Amnesia. *Journal of Experimental Child Psychology, 59*(3), 516-548
- Peterson, C. C., Peterson, J. L., & Webb, J. (2000). Factors influencing the development of a theory of mind in blind children. *British Journal of Developmental Psychology, 18*(3), 431-447.
- Peterson, C. C., & Siegal, M. (1995). Deafness, conversation and theory of mind. *Journal of child Psychology and Psychiatry, 36*(3), 459-474
- Phillips, W., Baron-Cohen, S., & Rutter, M. (1998). Understanding intention in normal development and in autism. *British Journal of Developmental Psychology, 16*(3), 337-348.
- Phillips, W., Gómez, J. C., Baron-Cohen, S., Laá, V., & Rivière, A. (1995). Treating people as objects, agents, or “subjects”: How young children with and without autism make requests. *Journal of Child Psychology and Psychiatry, 36*(8), 1383-1398.
- Pillemer, D. B. (1992). Remembering personal circumstances: A functional analysis.
- Platek, S. M., Critton, S. R., Myers, T. E., & Gallup, G. G. (2003). Contagious yawning: the role of self-awareness and mental state attribution. *Cognitive Brain Research, 17*(2), 223-227.
- Povinelli, D. J. (2001). The Self: Elevated in Consciousness and Extended in Time. In C. Moore & K. Lemmon (Eds.), *The Self in Time: Developmental Perspectives*. Mahwah: Lawrence Erlbaum Associates.
- Prior, H., & Schwarz, A. (2008). Mirror-induced behavior in the magpie (*Pica pica*): evidence of self-recognition. *PLoS biology, 6*(8), e202.

- Rankin, K. P., Baldwin, E., Pace-Savitsky, C., Kramer, J. H., & Miller, B. L. (2005). Self awareness and personality change in dementia. *Journal of Neurology, Neurosurgery & Psychiatry*, 76(5), 632-639.
- Rochat, P. (2003). Five levels of self-awareness as they unfold early in life. *Consciousness and cognition*, 12(4), 717-731.
- Rogers, S. J. (1999). An examination of the imitation deficit in autism.
- Rogers, T. B., Kuiper, N. A., & Kirker, W. S. (1977). Self-reference and the encoding of personal information. *Journal of Personality and Social Psychology*, 35(9), 677-688.
- Ross, H. S. (1996). Negotiating principles of entitlement in sibling property disputes. *Developmental Psychology*, 32(1), 90.
- Ross, L., & Nisbett, R. E. (1991). *The person and the situation: Perspectives of social psychology*. New York: McGraw-Hill Book Company.
- Ronald, A., Happe, F., Price, T. S., Baron-Cohen, S., & Plomin, R. (2006). Phenotypic and genetic overlap between autistic traits at the extremes of the general population. *Journal of the American Academy of Child & Adolescent Psychiatry*, 45(10), 1206-1214.
- Ronald, A., Happe, F., Bolton, P., Butcher, L. M., Price, T. S., Wheelwright, S., ... & Plomin, R. (2006). Genetic heterogeneity between the three components of the autism spectrum: a twin study. *Journal of the American Academy of Child & Adolescent Psychiatry*, 45(6), 691-699.
- Russell, J., & Jarrold, C. (1999). Memory for actions in children with autism: Self versus other. *Cognitive Neuropsychiatry*, 4(4), 303-331.
- Schacter, D. L., & Tulving, E. (1994). What are the memory systems of 1994? In D. Schacter, L. & E. Tulving (Eds.), *Memory Systems*. Cambridge, MA: The MIT Press.
- Schulman, A. H., & Kaplowitz, C. (1977). Mirror-image response during the first two years of life. *Developmental Psychobiology*, 10(2), 133-142.

- Shalom, D. B., Mostofsky, S. H., Hazlett, R. L., Goldberg, M. C., Landa, R. J., Faran, Y., ... & Hoehn-Saric, R. (2006). Normal physiological emotions but differences in expression of conscious feelings in children with high-functioning autism. *Journal of autism and developmental disorders*, 36(3), 395-400.
- Shantz, C. U. (1975). The development of social cognition. Review of child development research. In E. M. Hetherington (Ed.), *Review of child development research* Oxford: U Chicago Press.
- Shoemaker, S. (1994). Self-Knowledge and "Inner Sense": Lecture I: The Object Perception Model. *Philosophy and Phenomenological Research*, 249-269.
- Spiker, D., & Ricks, M. (1984). Visual self-recognition in autistic children: Developmental relationships. *Child Development*, 214-225.
- Squire, L., R. (2004). Memory systems of the brain: A brief history and current perspective. *Neurobiology of Learning and Memory*, 82(3), 171-177.
- Suddendorf, T., Simcock, G., Nielsen, E., & Collier-Baker, E. (2006). Video-self-recognition in children (*Homo sapiens*) and a chimpanzee (*Pan troglodytes*). In *21st Congress of the International Primatological Society*.
- Suddendorf, T., Simcock, G., & Nielsen, M. (2007). Visual self-recognition in mirrors and live videos: Evidence for a developmental asynchrony. *Cognitive Development*, 22(2), 185-196.
- Symons, C. S., & Johnson, B. T. (1997). The Self-Reference Effect in Memory: A Meta-Analysis. *Psychological Bulletin*, 121(3), 371-394.
- Tastevin, J. (1937). En partant de l'expérience d'Aristote les déplacements artificiels des parties du corps ne sont pas suivis par le sentiment de ces parties ni par les sensations qu'on peut y produire. *L'Encéphale: Revue de psychiatrie clinique biologique et thérapeutique*.



- Toichi, M., Kamio, Y., Okada, T., Sakihama, M., Youngstrom, E. A., Findling, R. L., & Yamamoto, K. (2002). A lack of self-consciousness in autism. *American Journal of Psychiatry*, 159(8), 1422-1424.
- Toichi, M., Kamio, Y., Okada, T., Sakihama, M., Youngstrom, E. A., Findling, R. L., et al. (2002). A lack of self-consciousness in autism. *The American journal of psychiatry*, 159(8), 1422-1424.
- Tsakiris, M., & Haggard, P. (2005). The rubber hand illusion revisited: visuotactile integration and self-attribution. *Journal of Experimental Psychology: Human Perception and Performance*, 31(1), 80.
- Tulving, E. Elements of episodic memory, 1983.
- Tulving, E. (1985). Memory and Consciousness. *Canadian Psychology*, 26(1), 1 - 12.
- Tversky, A., & Kahneman, D. (1974). Judgment under Uncertainty: Heuristics and Biases. *Science*, 185(4157), 1124-1131.
- Uddin, L. Q. (2011). The self in autism: An emerging view from neuroimaging. *Neurocase*, 17(3), 201-208.
- Uddin, L. Q., Davies, M. S., Scott, A. A., Zaidel, E., Bookheimer, S. Y., Iacoboni, M., & Dapretto, M. (2008). Neural basis of self and other representation in autism: an FMRI study of self-face recognition. *PloS one*, 3(10), e3526.
- Wechsler, D. (2008). Wechsler Adult Intelligence Scale–Fourth Edition (WAIS–IV). *San Antonio, TX: NCS Pearson*.
- Welch, R. B., Widawski, M. H., Harrington, J., & Warren, D. H. (1979). An examination of the relationship between visual capture and prism adaptation. *Perception & Psychophysics*, 25(2), 126-132.
- Wheeler, M. A., Stuss, D. T., & Tulving, E. (1997). Toward a Theory of Episodic Memory: The Frontal Lobes and Autonoetic Consciousness. *Psychological Bulletin*, 121(3), 331-354.

- Williams, D. (2010). Theory of own mind in autism Evidence of a specific deficit in self-awareness?. *Autism, 14*(5), 474-494.
- Williams, D., & Happe, F. (2009). What Did I Say? Versus What Did I Think? Attributing False Beliefs to Self Amongst Children With and Without Autism. *Journal of Autism and Developmental Disorders, 39*(6), 865-873.
- Williams, D., & Happé, F. (2010). Representing intentions in self and other: studies of autism and typical development. *Developmental Science, 13*(2), 307-319.
- Williams, D. M., Jarrold, C., Grainger, C., & Lind, S. E. (2014). Diminished time-based, but undiminished event-based, prospective memory among intellectually high-functioning adults with autism spectrum disorder: Relation to working memory ability. *Neuropsychology, 28*(1), 30.
- Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition, 13*(1), 103-128.
- Wing, L. (1981). Sex ratios in early childhood autism and related conditions. *Psychiatry Research, 5*(2), 129-137.
- Wing, L., & Gould, J. (1979). Severe impairments of social interaction and associated abnormalities in children: Epidemiology and classification. *Journal of autism and developmental disorders, 9*(1), 11-29.
- Woodbury-Smith, M. R., Robinson, J., Wheelwright, S., & Baron-Cohen, S. (2005). Screening adults for Asperger syndrome using the AQ: A preliminary study of its diagnostic validity in clinical practice. *Journal of autism and developmental disorders, 35*(3), 331-335.
- World Health Organization. Director-General. (2003). *The World Health Report: Report of the Director-General*. World Health Organization.

Yiend, J., Mackintosh, B., & Mathews, A. (2005). Enduring consequences of experimentally induced biases in interpretation. *Behaviour Research and Therapy*, 43(6), 779-797.

**Appendix One: Word stimuli used in experiment 1.1, 2.1 and 2.2.**

<b>Word</b>	<b>Version One</b>	<b>Version Two</b>	<b>Version Three</b>
<b>Able</b>	Other	Lure	Self
<b>Abnormal</b>	Self	other	Lure
<b>Adorable</b>	Other	Lure	Self
<b>Aggressive</b>	Lure	Self	Other
<b>Alluring</b>	Other	Lure	Self
<b>Angelic</b>	Lure	Self	Other
<b>Angry</b>	Self	Other	Lure
<b>Angular</b>	Other	Lure	Self
<b>Anxious</b>	Other	Lure	Self
<b>Asymmetric</b>	Other	Lure	Self
<b>Average</b>	Lure	Self	Other
<b>Bashful</b>	Lure	Self	Other
<b>Beautiful</b>	Lure	Self	Other
<b>Blemished</b>	Other	Lure	Self
<b>Bloated</b>	Self	Other	Lure
<b>Blunt</b>	Other	Lure	Self
<b>Bold</b>	Self	Other	Lure
<b>Boyish</b>	Lure	Self	Other
<b>Bronzed</b>	Lure	Self	Other
<b>Bronzy</b>	Lure	Self	Other
<b>Brunet</b>	Self	Other	Lure
<b>Bulky</b>	Other	Lure	Self
<b>Burly</b>	Other	Lure	Self
<b>Calm</b>	Self	Other	Lure
<b>Careful</b>	Lure	Self	Other
<b>Cautious</b>	Self	Other	Lure
<b>Childlike</b>	Lure	Self	Other
<b>Choosy</b>	Lure	Self	Other
<b>Clownish</b>	Lure	Self	Other
<b>Clumsy</b>	Other	Lure	Self
<b>Colossal</b>	Other	Lure	Self
<b>Compulsive</b>	Self	Other	Lure
<b>Crafty</b>	Self	Other	Lure
<b>Cunning</b>	Lure	Self	Other
<b>Curious</b>	Lure	Self	Other
<b>Cute</b>	Lure	Self	Other
<b>Cynical</b>	Other	Lure	Self
<b>Definite</b>	Lure	Self	Other
<b>Delicate</b>	Self	Other	Lure
<b>Dependant</b>	Lure	Self	Other
<b>Dimpled</b>	Other	Lure	Self
<b>Direct</b>	Other	Lure	Self
<b>Disabled</b>	Lure	Self	Other
<b>Discreet</b>	Self	Other	Lure
<b>Dollish</b>	Other	Lure	Self
<b>Eager</b>	Self	Other	Lure

<b>Eccentric</b>	Other	Lure	Self
<b>Elderly</b>	Other	Lure	Self
<b>Enormous</b>	Self	Other	Lure
<b>Exotic</b>	Lure	Self	Other
<b>Fair</b>	Other	Lure	Self
<b>Female</b>	Self	Other	Lure
<b>Feminine</b>	Self	Other	Lure
<b>Forceful</b>	Self	Other	Lure
<b>Fragile</b>	Self	Other	Lure
<b>Giant</b>	Self	Other	Lure
<b>Gigantic</b>	Other	Lure	Self
<b>Girlish</b>	Self	Other	Lure
<b>Glamorous</b>	Self	Other	Lure
<b>Gracious</b>	Self	Other	Lure
<b>Hairy</b>	Other	Lure	Self
<b>Headstrong</b>	Self	Other	Lure
<b>Heavy</b>	Lure	Self	Other
<b>Helpless</b>	Self	Other	Lure
<b>Humble</b>	Other	Lure	Self
<b>Imitative</b>	Other	Lure	Self
<b>Impractical</b>	Other	Lure	Self
<b>Impulsive</b>	Self	Other	Lure
<b>Inconsistent</b>	Lure	Self	Other
<b>Indecisive</b>	Lure	Self	Other
<b>Lanky</b>	Self	Other	Lure
<b>Lazy</b>	Lure	Self	Other
<b>Lean</b>	Other	Lure	Self
<b>Light</b>	Self	Other	Lure
<b>Little</b>	Lure	Self	Other
<b>Luscious</b>	Self	Other	Lure
<b>Male</b>	Other	Lure	Self
<b>Manly</b>	Lure	Self	Other
<b>Meaty</b>	Lure	Self	Other
<b>Miniature</b>	Other	Lure	Self
<b>Miniscule</b>	Self	Other	Lure
<b>Minute</b>	Lure	Self	Other
<b>Moderate</b>	Self	Other	Lure
<b>Moody</b>	Self	Other	Lure
<b>Mousy</b>	Lure	Self	Other
<b>Mustacheless</b>	Other	Lure	Self
<b>Narrow</b>	Lure	Self	Other
<b>Negligent</b>	Lure	Self	Other
<b>Neurotic</b>	Other	Lure	Self
<b>Nice</b>	Self	Other	Lure
<b>Pasty</b>	Lure	Self	Other
<b>Pert</b>	Other	Lure	Self
<b>Pompous</b>	Other	Lure	Self
<b>Popular</b>	Self	Other	Lure
<b>Positive</b>	Lure	Self	Other

<b>Precise</b>	Lure	Self	Other
<b>Profane</b>	Other	Lure	Self
<b>Prudent</b>	Self	Other	Lure
<b>Pubescent</b>	Other	Lure	Self
<b>Quick</b>	Lure	Self	Other
<b>Rash</b>	Other	Lure	Self
<b>Rational</b>	Lure	Self	Other
<b>Reckless</b>	Self	Other	Lure
<b>Religious</b>	Self	Other	Lure
<b>Rosy</b>	Lure	Self	Other
<b>Rugged</b>	Self	Other	Lure
<b>Sarcastic</b>	Self	Other	Lure
<b>Scolding</b>	Lure	Self	Other
<b>Sculpturesque</b>	Self	Other	Lure
<b>Serious</b>	Other	Lure	Self
<b>Shrewd</b>	Self	Lure	Other
<b>Silent</b>	Self	Other	Lure
<b>Skilful</b>	Other	Lure	Self
<b>Skinny</b>	Other	Lure	Self
<b>Slender</b>	Lure	Self	Other
<b>Slight</b>	Lure	Self	Other
<b>Sloppy</b>	Self	Other	Lure
<b>Smug</b>	Other	Lure	Self
<b>Statuesque</b>	Lure	Self	Other
<b>Stingy</b>	Lure	Self	Other
<b>Stocky</b>	Self	Other	Lure
<b>Strict</b>	Other	Lure	Self
<b>Stubborn</b>	Other	Lure	Self
<b>Studious</b>	Self	Other	Lure
<b>Sturdy</b>	Other	Lure	Self
<b>Suave</b>	Lure	Self	Other
<b>Submissive</b>	Lure	Self	Other
<b>Tall</b>	Lure	Self	Other
<b>Thickset</b>	Lure	Self	Other
<b>Thin</b>	Other	Lure	Self
<b>Timid</b>	Other	Lure	Self
<b>Tiny</b>	Self	Other	Lure
<b>Tiresome</b>	Self	Other	Lure
<b>Tubby</b>	Self	Other	Lure
<b>Unhealthy</b>	Other	Lure	Self
<b>Unique</b>	Self	Other	Lure
<b>Unpoised</b>	Self	Other	Lure
<b>Unpunctual</b>	Lure	Self	Other
<b>Unusual</b>	Lure	Self	Other
<b>Vain</b>	Self	Other	Lure
<b>Vigourous</b>	Other	Lure	Self
<b>Vivacious</b>	Other	Lure	Self
<b>Wasteful</b>	Lure	Self	Other
<b>White</b>	Self	Other	Lure

<b>Wiry</b>	Self	Other	Lure
<b>Withdrawn</b>	Other	Lure	Self
<b>Womanish</b>	Self	Other	Lure
<b>Womanlike</b>	Lure	Self	Other
<b>Womanly</b>	Lure	Self	Other
<b>Young</b>	Lure	Self	Other

**Appendix two: Word Stimuli used in Experiments 3.1 and 3.2.**

<b>Adjective</b>	<b>Type</b>	<b>List</b>
Brainy	Psychological	One
Sad	Psychological	One
Careful	Psychological	One
Cheerful	Psychological	One
Good	Psychological	One
Funny	Psychological	One
Busy	Psychological	One
Brave	Psychological	One
Sneaky	Psychological	One
Clumsy	Psychological	One
Pale	Physical	One
Short	Physical	One
Giant	Physical	One
Strong	Physical	One
Ugly	Physical	One
Enormous	Physical	One
Plain	Physical	One
Dark-Haired	Physical	One
Young	Physical	One
Thin	Physical	One
Boring	Psychological	Two
Strange	Psychological	Two
Bossy	Psychological	Two
Neat	Psychological	Two
Mean	Psychological	Two
Annoying	Psychological	Two
Rude	Psychological	Two
Nice	Psychological	Two
Friendly	Psychological	Two
Greedy	Psychological	Two
Grownup	Physical	Two
Gigantic	Physical	Two
Wrinkled	Physical	Two
Little	Physical	Two
Blonde	Physical	Two
Boy	Physical	Two
Sporty	Physical	Two
Hairy	Physical	Two
Old	Physical	Two
Beautiful	Physical	Two
Messy	Psychological	Three
Clever	Psychological	Three
Wise	Psychological	Three
Big	Psychological	Three
Kind	Psychological	Three
Serious	Psychological	Three
Nosey	Psychological	Three
Lazy	Psychological	Three



Angry	Psychological	Three
Happy	Psychological	Three
Girl	Physical	Three
Pretty	Physical	Three
Adult	Physical	Three
Tall	Physical	Three
Bald	Physical	Three
Skinny	Physical	Three
Tiny	Physical	Three
Child	Physical	Three
Scruffy	Physical	Three
Small	Physical	Three

**Appendix three: List of Picture cards used in experiments 7.1 and 7.2.**

*Appendix One: List of Picture Items used.*

List One

Alarm  
Aubergine  
Bagel  
Bananas  
Bleach  
Broccoli  
Cakes  
Pie  
Cauliflower  
Champagne  
Cherries  
Chilli  
Chops  
Coathanger  
Cocktail Sticks  
Courgettes  
Crumpets  
Crisps  
Garlic  
Goggles  
Green beans  
hairdryer  
Hammer  
iPod  
Jug  
Mouthwash  
Lager  
Lollipop  
Microwave  
Milk  
Mug  
Orange Juice  
Pasta  
Torch  
Pineapple  
Plant  
Plaster  
Rolling Pin  
Sandwich  
Socks  
Scissors  
Slippers  
Soap  
Spanner  
String

Teapot  
Towels  
Radio  
Washing-up  
Liquid  
Jam  
Coconut  
Camera  
Water  
Vaseline  
Turnip  
Superglue  
Soup  
Golden Syrup  
Strawberry  
Sellotape  
Red Wine  
Pop corn  
Melon  
Lime  
Jeans  
Syrup  
Fork  
Dental Floss  
Chocolate  
Briefcase  
Blender  
Loofah  
Batteries

List Two

Apple  
Avocado  
Baked beans  
Bin  
Blueberries  
Bucket  
Candle  
Cashew nuts  
Cheese  
Chicken  
Clothes pegs  
Coconut  
Cookie  
Crackers  
Flour  
Cucumber  
Deodorant  
Dustpan  
Flowers  
Frying pan  
Gin  
Grapefruit

Hairbrush  
Hat  
Iron  
Ketchup  
Knife  
Ladle  
Leeks  
Lightbulb  
Matches  
Mince  
Nail Clippers  
Olive Oil  
Paintbrush  
Peaches  
Pepper  
Pizza  
Potatoes  
Vodka  
Rucksack  
Sausages  
Shirt  
Sponge  
Suitcase  
Tissues  
Toothpaste  
Vinegar  
Watch  
Wineglasses  
Peas  
DVD Player  
Whisky  
Vacuum  
Cleaner  
Teabags  
Sweetcorn  
Stock Cubes  
Shampoo  
Sieve  
Salt  
Raisins  
Plate  
Lipstick  
Lentils  
Jacket  
Gammon  
Felt Tips  
Cough Sweets  
Cabbage  
Blu Tack  
Parsnips  
Pancakes  
Yoghurt

### List Three

Apron  
Bacon  
Baking tray  
Binoculars  
Bread  
Butter  
Cap  
Casserole  
Celery  
Chair  
Cheese grater  
Chickpeas  
Chocolate  
Chopping  
board  
Coffee  
Coke  
Corkscrew  
Crayons  
Cream  
Croissant  
Doughnut  
Eggs  
Gloves  
Grapes  
Hot chocolate  
Whisk  
kettle  
Lemon  
Lettuce  
lighter  
Kiwi  
Mushrooms  
Newspaper  
Onion  
Parsley  
pear  
Carrots  
Rake  
Raspberries  
Razor  
Salmon  
Scarf  
Spade  
Stapler  
Sunglasses  
Toaster  
Tomatoes  
Pen  
Watermelon  
Wooden  
Spoon  
Bowl  
Biscuits

Washing  
Powder  
Toothbrush  
Tin Opener  
Shoes  
Shrimp  
Spinach  
Sugar  
Roasting Tray  
Quiche  
Paracetamol  
Mayonaise  
Jelly  
Herbs  
Fish  
Egg Cup  
Cornflakes  
Chewing Gum  
Porridge  
Pasta Sauce  
Air Freshener